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The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES — WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION — CARGO HANDLING APPLIANCES

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Mr. W. H. McMenemey has been appointed engineering manager of Cammell Laird & Co. Ltd., Birkenhead, in succession to Mr. George Hudson Wright, C.B.E.

Mr. D. Landale Frew, 45, Hope Street, Glasgow, has been appointed Sole Agent in Scotland of Hollings & Guest Limited, hydraulic engineers, Thimble Mill Lane, Birmingham.

Sir William Gray, Bart., Tunstall Manor, has been presented with his portrait in oils by the employees of the Hartlepool shipyards and the Central Marine Engine Works of William Gray & Co. Limited.

Mr. Henry Radcliffe, J.P., the well-known Cardiff shipowner, whose death occurred on December 16 at the age of 64 years, was to a large extent responsible for the development of the Cardiff Channel Dry Docks & Pontoon Company Limited. In addition to being a director of that enterprise he was on the Board of the subsidiary concerns, the Barry Graving Dock & Engineering Company Limited, the Bute Shipbuilding, Engineering & Dry Dock Company Limited, the Mercantile Pontoon Company Limited, and the Tredegar Dry Dock & Wharf Company Limited. Mr. Radcliffe was head of the firm of Evans Thomas, Radcliffe & Co., of Cardiff.

Sir James McKechnie, the head of Vickers' business at Barrow-in-Furness, has left England on a business trip to the United States and Canada. He travelled from Liverpool on the Cunarder *Scythia*, a notable recent production of Vickers Limited, which is doing excellently on service, and in the course of the voyage to New York he intended to observe the performance of the ship generally and her double-reduction geared turbine propelling machinery particularly. While on the other side of the Atlantic Sir James will deal with a number of business matters calling for attention. The expectation is that he will be back in England some time in January.

Mr. Norman M. Hunter, manager of the West Shipyard of Barclay, Curle & Co. Ltd., Glasgow, has been appointed by Swan, Hunter & Wigham Richardson Ltd., as general manager at Wallsend-on-Tyne. Mr. Hunter, who will take up his new duties early in January, went to the Clyde some nine years ago, when Barclay, Curle & Co. took over the West Yard at Scotstoun, and had it transformed into an up-to-date establishment designed on the most modern lines. In the laying out of the yard Mr. Hunter took a prominent part, and much of its subsequent success has been due to his capable management. Before going to the Clyde he was for about four years with Cammell Laird & Co. Ltd., at Tranmere Bay, where he was also largely responsible for the establishment of the new works there. Mr. Hunter is very popular in the Clyde district, and keen regret will be felt in shipbuilding circles at his departure.

Among the naval architects and marine engineers at Glasgow who have devoted a good deal of attention to questions relating to improvements in ship design and in appliances used on board ships, is Mr. Alexander Dey, of the Naval Architects' Department of the Anchor Line. Mr. Dey was trained in the practical work of shipbuilding on the Clyde, and for a time was employed in the well-known Meadowside Shipyard, after which he was on the staff of Sir J. H. Biles & Co., naval architects. During the latter years of the war he served in the Department of the Steel Controller for Scotland under Mr. G. P. West, and about two years ago he entered the Naval Architects' Department of the Anchor Line. Last autumn Mr. Dey published particulars relating to an improved design for ships' hatch covers, and more recently he has brought out two sets of designs for the construction of double bottoms of ships. Mr. Dey is also a frequent contributor to the discussions on technical papers read before the Institution of Engineers and Shipbuilders in Scotland.

Commodore Charles A. Bartlett, C.B., C.B.E., R.D., R.N.R., who was recently elected to the Council of the Mercantile Marine Service Association, is the Senior Marine Superintendent of the White Star Line. Commodore Bartlett served his apprenticeship with D. Bruce, of Dundee, who owned a fleet of clipper ships, and afterwards entered the British India Company's service, in which he continued until 1894, when he joined the White Star Line. He was in command of White Star liners until 1912, when he was promoted to his present position. From 1915 to 1916 he was in command of H.M.'s hospital ship *Britannic*, during which time he was honoured with the C.B. in recognition of his services during the war. At a later date he was created C.B.E. In 1907 the Reserve Decoration was granted him by King Edward for service in the R.N.R., and he was recently promoted to Commodore R.N.R. on the retired list. In addition to the foregoing honours, Commodore Bartlett served as an Aide-de-Camp to H.M. the King. He is also a Younger Brother of Trinity House and a member of the Advisory Committee of the R.N.R. Commodore Bartlett has lately shown practical sympathy with the navigating officers out of employment by inaugurating the system of collections among the masters and officers on White Star Line vessels for their benefit.

EDITORIAL.

MARINE ENGINEERING TO-DAY.

AT no time in the history of marine engineering has the marine engineer had to contend with such a variety of machinery as to-day. The triple-expansion engine—and the steam reciprocating engine generally—so often believed to be tottering to its fall, still holds a firm place in the industry, although in recent years the development of geared turbines and Diesel engines has undoubtedly shaken the indisputable sway throughout the whole of the mercantile marine held at one time by the reciprocating steam engine. Undoubtedly the war was responsible for the rapid development of the geared turbine. It was taken up with avidity in the United States; and although many of the attempts proved costly, through lack of experience, other installations were sufficiently successful to reassure owners of the usefulness and economy of this particular type.

Output of 11 Engineering Firms, 1921.

—	Reciprocating Engines.		Geared Turbines.		Diesel Engines.		Total H.P.
	No.	H.P.	No.	H.P.	No.	H.P.	
	sets		sets		set		
Richardsons, Westgarth & Co., Hartlepool, Middlesbrough and Sunderland	22	58,280	3	16,200	—	—	74,480
N.E. Marine Engineering Co., Wallsend and Sunderland	16	36,420	2	6,400	1	1,400	44,220
J. G. Kincaid & Co., Greenock	16	40,600	1	6,000	—	—	46,600
Wallsend Slipway & Engineering Company	2	7,200	5	43,110	—	—	50,310
D. Rowan & Co., Glasgow	9	21,400	3	15,800	—	—	37,200
Blair & Co., Stockton-on-Tees	12	31,300	—	—	—	—	31,300
George Clark Limited, Sunderland	3	—	2	—	—	—	14,210
John Dickinson & Sons, Sunderland	4	13,058	—	—	—	—	13,058
Rankin & Blackmore, Greenock	5	12,000	—	—	—	—	12,000
McKie & Baxter, Glasgow	28	19,730	—	—	—	—	19,730
C. D. Holmes & Co., Hull	12	6,455	—	—	—	—	6,455
Totals	129	246,423	16	87,510	1	1,400	349,543

Perhaps also the popularity of the geared turbine and the extension of oil fuel have had something to do with retarding the development of the Diesel engine. In spite of statements that are sometimes made, this is not yet the Diesel engine age, although it is true that in late years enormous strides have been made towards the perfection and development of the Diesel engine. But a study of the returns of engineering establishments for the past year shows that the Diesel engine propels but a small proportion of the new tonnage. In the above table we have analysed the returns of some of the principal marine engineering establishments up to the present concerned with steam practice. By marine engineering establishments we mean those which are devoted exclusively to the manufacture of machinery and do not build hulls. Doubtless if the output of combined shipbuilding and marine engineering concerns were examined it would alter the proportion, but mainly in the direction of showing a larger horse-power of geared turbine machinery. The development of the Diesel engine is, however, proceeding on sound lines and nearly every engine builder in now ready to supply Diesel and other oil engines to the shipowners' requirements.

It will be seen, however, that the table bears out our contention that marine engineering firms are on the whole occupied with a great variety of types. As there are those who believe that the engine of the future lies with none of those with which we are familiar, it is evident that the problem for the investigator is one of increasing complexity and necessitates more than ever an open mind and access to information from all sources.

If we leave the main propelling machinery and direct our attention to the auxiliaries the field is even greater and more varied still. Steam, electricity, and oil play their part. We have hydraulic winches; steam, hydraulic and electro-hydraulic steering gear; passenger lifts; and other things hardly considered within the orbit of marine engineering less than 20 years ago. All these machines have to be manufactured and count in no small measure as part of the industrial equipment of the nation. They involve careful scrutiny by the technical experts of our shipowners in order that ships may be propelled, handled, loaded and discharged on an economical basis; and they necessitate from the sea-going engineer a high standard of mechanical training and efficiency.

PROPELLERS FOR DIESEL-ENGINED SHIPS.

IT is not sufficient that engineers should be able to produce machinery economical in consumption of fuel and with a high ratio of power per unit of weight. It is above all necessary that it should be suitable for the purpose intended. Certain restrictions are imposed by the conditions to be met and ship machinery must be designed to suit these limiting conditions.

When turbine machinery was first used for ship propulsion the revolutions were extremely high. Fortunately for the initial success of this system of propulsion, the *Turbinia* lent itself more readily to being driven by small screws than many other types of vessels would. Originally in that vessel several small screws were attached to each shaft; with the gradual development of the application of turbine machinery multiple screws were discarded as being an inefficient method of propulsion. It was soon found that if the full advantage of turbine machinery was to be obtained some means would require to be introduced whereby reasonably high propeller efficiencies would be possible. In some of the earlier direct-driven turbine destroyers propulsive efficiencies of around 45 per cent. were usually obtained; with the introduction of gearing this has been greatly increased. The necessity for small diameter in the screws for direct-driven vessels caused these to work at high slips before the requisite thrust was produced. Not only so, but the surface necessary to obviate cavitation dangers caused the disc area ratios to be much higher than that associated with maximum efficiency. Further, the pitch ratios which promised the best efficiencies for the given conditions were well under unity, and the introduction of gearing has enabled pitch ratios of 1·2 and above to be adopted, with marked improvement in results.

Because of the necessity for very high rotary speeds and the impossibility of securing reasonable propeller efficiency with direct drive, the ordinary merchant ship was found to be outside the field of application of turbine machinery. Not until the *Vespasian* experiments with tooth gearing were successfully accomplished did the turbine become a feasible proposition for merchant ships. Now the propeller problem is investigated at the earliest stages of design and the revolutions of the

turbines and also of the screws are determined in the light of the best all-round efficiency and the limitations of double reduction gear.

Oil engines have a wide field of usefulness in slow cargo vessels and all merchant ships of moderate power and speed. The propeller problem in these vessels is one of great interest, for the Diesel engine demands a rate of revolution much higher than that generally adopted in slow and moderate speed merchant vessels. In an ordinary single-screw cargo tramp of about 10,000 tons displacement fitted with reciprocating steam machinery a propeller of about 17 ft. diameter would be fitted, revolving at approximately 70 r.p.m. In motor-driven vessels it is found advisable to divide the power; thus twin-screw motor vessels are much commoner than those driven by a single screw. This dividing of the power enables a reasonably high rate of revolutions to be given to the engines and still secures moderately good screw efficiency.

In the article on pages 21 and 26 dealing with this subject, the cases of two motor ships and one driven with reciprocating steam machinery are considered. An attempt has been made to analyse the records given and to find out the values of the various factors in the separate cases. Evidently the writer of that article has not yet arrived at a definite conclusion as to the actual values of wake, thrust deduction, propeller and hull efficiencies, for those suggested by analysis are vastly different from those met with in ordinary practice. Take the *Suecia*, for example; by analysis a wake of 95 per cent. has been obtained, whereas Mr. Blache, of Burmeister & Wain, assumed a wake of 16·5 per cent. At first sight it appears that that given by the analysis is much higher than is probable, and, perhaps, that given by Mr. Blache is lower than might have been chosen. The latter was determined by a formula based on experimental results, but it is probable that those experimental results were very meagre as regards scope and type. Some recent results which have come under our observation have shown that with full cargo ships wakes of over 100 per cent. have been obtained. Knowing this, one is inclined to await with patience the further development of the article appearing in our columns.

There is little doubt but that abnormal conditions may be produced when a tolerably heavy vessel is being driven by screws small in diameter revolving at a high rate of revolutions. It may be that an analysis of such a trial will reveal values which are beyond those obtained in average conditions. Perhaps, also, our ideas as to "wake gain" may require to be modified, or enlarged, so as to account for the gross propulsive efficiencies obtained.

The case of the *Eavestone* is one of some difficulty, for if the analysis is to be believed a mechanical efficiency of a little over 50 per cent. was given. This statement would be stoutly contested by any engineer. Even on this point one is chary of dogmatising, for the average engineer will claim that mechanical efficiencies of 80 per cent. and above are quite usual for steam reciprocating engines. That may be so, but trial analysis seldom bears out this claim. When builders of oil engines are working on the assumption that the shaft horse-power is 75 per cent. of that indicated, it may be safely assumed that where special care has not been taken in the fitting up of the machinery the frictional losses may be even more than the 25 per cent. allowed. Not that we suggest that this has actually taken place in the *Eavestone*, but merely that this question of mechanical efficiency is a very open one, requiring better determination.

It has frequently been remarked that although single screws are most advantageously placed with regard to the wake the performances of single screw vessels do not indicate any marked superiority over those of twin-screw ships. In the cases analysed the *Suecia*—twin screw—shows the highest wake of the three. This may be the case or otherwise, but quite a reasonable explanation lies in the possibility that the screws are so close to the frictional wake clinging to the bossings that they gain some advantage therefrom.

We would suggest in conclusion that it is incumbent on engineers who publish results of trials that the accuracy of their data should be unquestioned. We have every confidence in the figures given for the *Suecia* and *Prinsessan Ingeborg*, and merely voice our appeal for accuracy so that by such methods of analysis our knowledge of the factors which unite to ensure propulsion might be enlarged and established.

CAST IRON.

THE majority of thoughtful engineers have long been aware of the fact that while in almost every branch of engineering design it is possible to proceed with a large measure of scientific accuracy, in all that appertains to cast iron no such accuracy is possible, for the simple reason that it is impossible to rely upon the mechanical properties of cast iron. The engineer has come to regard cast iron as an unreliable material, and hence in all his designing work he tries as far as possible to dispense with this particular material or else he uses a large factor of safety in order to protect himself against the uncertainty regarding the exact strength of the cast iron he is working into his design. In the paper, "The Problem of Grey Iron Castings," which he read last month before the Institute of Marine Engineers, Mr. H. J. Young has rendered good service to the engineering profession.

In the first place, Mr. Young draws attention to the fact that the foundries are run on rule-of-thumb methods, which, while they set out to give a cast iron of stated specification, yet produce material which varies very considerably in its properties. Mr. Young, in his position as Chief Metallurgist to the North Eastern Marine Engineering Company, has had an opportunity of testing the composition of a large number of different specimens of iron both before and after it has been cast, and as a result he finds that not only does the chemical composition—and with it, of course, the mechanical properties—of the iron vary as between different consignments, but even in the same consignment the composition varies between very wide limits. Thus, in one consignment of 280 tons, as a result of 23 analyses, it was found that the silicon content varied between 2·4 per cent. and 4·7 per cent., and, further, no two consignments possess similar or equal variations, so that it is impossible to predict the exact composition or even to strike an average. Similarly, with regard to analyses for phosphorus, sulphur and manganese. These also vary within wide limits. It is easily understandable, therefore, that the mechanical properties of the castings made from these pigs after melting in the cupola will also show considerable variation, although the control which is possible, even with the present lack of measuring instruments, enables castings of more or less uniform composition to be produced.

It may be said that the problem of producing uniform castings of dependable strength demands not only the production of a material of uniform composition in the cupola, but also the adoption of methods of casting which shall ensure practically uniform cooling. Whether such is possible at the present state of our knowledge of the subject is open to question, but that it is extremely desirable no one will deny. We are endeavouring to raise the working temperatures in our engines, and we want, if possible, to lighten their structure, and for this purpose we require a cast iron of superior qualities to that available to-day. We agree with the author of this paper that the whole system governing the production of cast iron needs overhauling; right from the blast-furnace to the final cooling of the casting each separate process needs to be studied scientifically with a view to applying at each step those exact methods which have proved so successful in other branches of metallurgy and engineering. There is a Cast Iron Research Association in existence which, if it is given sufficient support, should be in a position to attack this problem with the object of drawing up a standard specification for cast iron with standardised methods of producing it.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Calvert's Mechanics' Almanack, 1922. Edited by Frank Nasmith and James McLachlan. Manchester: John Heywood Limited, Deansgate. London: 22, St. Bride Street, E.C. 4. $4\frac{1}{8}$ in. × $6\frac{1}{2}$ in. × $\frac{1}{4}$ in. Price 6d. net. 176 pages.

A work of this character which is approaching its jubilee—the present is the 49th edition—obviously needs no special recommendation. It is small in size, and as it is sold at 6d. one can be assured of obtaining value for money.

Handbook of Standard Details. By Charles H. Hughes. London: D. Appleton & Co., 25, Bedford Street, Covent Garden, W.C. 2. $4\frac{7}{8}$ in. × $7\frac{1}{4}$ in. × 1 in. 312 + x pages. Illustrated. Price 25s.

Mr. Hughes is the author of the "Handbook of Ship Calculations, Construction and Operation," and in the present volume discusses standard details as applied to all aspects of engineering. The tables are very comprehensive and the various illustrations well produced and clearly printed. There is an extensive index which adds to the usefulness of the book as a reference work.

Modern Methods of Welding. By J. H. Davies. London: Constable & Co. Limited, 10, Orange Street, Leicester Square, W.C. $5\frac{3}{4}$ in. × 9 in. × $\frac{7}{8}$ in. 263 + xviii pages. Price 21s.

In this work Mr. Davies gets right down to the practical side of the subject. He starts off with a chapter on welding in general, and after discussing the manufacture of oxygen, hydrogen, carbide, the general construction and treatment of acetylene generators and so on, brings his reader to the question of blowpipes, flexible tubes, safety valves, purifiers, and the broader aspects of installation. From these he comes on to the actual methods of welding the various metals, subsequently discussing the various tests which may be applied to the finished weld. Electric arc welding is treated separately in a series of chapters towards the end of the book.

Fuel and Lubricating Oils for Diesel Engines. By W. Schenker. London: Constable & Co. Limited, 10, Orange Street, Leicester Square, W.C. 2. $5\frac{3}{4}$ in. × 9 in. × $\frac{1}{2}$ in. 114 + xii pages. Price 10s.

Mr Schenker is Chief Engineer of the Diesel Engine Department of Sulzer Frères, and is consequently an authority on a subject which is not only interesting but of vital moment to all users of Diesel engines. This is not a big book in the ordinary sense of the word, but it is wonderfully full of information, and Mr. Schenker not only contrives to deal with the characteristics and uses of fuel and lubricating oils, but also gives an insight into the methods of production and treatment of the raw products. The volume is not confined to petroleum, but deals also with tars, coal tar distillates, vegetable oils and alcohols. The work includes a number of tables useful to engineers.

Applied Calculus. By F. F. P. Bisacre, O.B.E., M.A. (Cantab.), B.Sc. (Lond.), A.M.inst.C.E. London: Blackie & Son Limited, 50, Old Bailey. $5\frac{3}{8}$ in. × 8 in. × $1\frac{1}{4}$ in. 446 + xiv pages. Price 10s. 6d. net.

Undoubtedly the greatest stumbling-block to the understanding of the calculus is a defective knowledge of elementary mathematics, and it is through lack of a proper foundation that students soon come to grief after working through first chapters of the average book on the subject; yet a surprising number of books on the calculus are brought out professing to have been specially written for those whose preliminary mathematical equipment is slack. Mr. Bisacre's book comes out with the same aims. Whether it will succeed in helping the student will depend entirely upon how much elementary mathematics the latter has assimilated. We often feel that in studying works of this character the trouble first arises through a divergence of opinion as between, say, a student at a technical school and a professor of mathematics as to what is elementary knowledge. Having overcome this point and brought the student's standard somewhat higher than he himself would fix as the minimum, we have no doubt that Mr. Bisacre's book will prove of real assistance, and if any cannot get along with it we should be inclined to blame his own defective mathematical sense.

"Der Schraubenpropeller." (Second edition.) By C. Dreihardt. Published by M. Krayn, Berlin. $6\frac{3}{4}$ in. × $10\frac{1}{4}$ in. 83 pp. 75 ff. and 7 tables. Price (in Germany), 26 marks.

The treatment of this work on screw propellers is much more practical than theoretical. The author, whilst making no reference to the researches of the experiment tanks, uses formulæ for the determination of the size and characteristics of propellers which closely resemble those generally used by the well-known research workers. Each chapter considers a particular aspect of the problem. They are:—General, Diameter, Pitch, Developed Area, Example, Changing Pitch Screws, Adjustable Blades, Turbine Propellers, Construction of Propellers, Manufacture of Propellers, and finally, Ship Resistance.

From a practical and constructional point of view the treatment is good, and much interesting information on such patent propellers as the Zeise and Niki types is given. The style of the first edition, which was published in 1906, has been generally preserved, and this second edition contains some additional chapters and plates which serve to bring the work more up to date.

"Der Kleinschiffbau." (Part I.) By Dr. E. Sachsenberg. Published by Julius Springer, Berlin. $7\frac{3}{4}$ in. × $10\frac{3}{4}$ in. x + 262 pp. 165 ff. Price (in Germany), 62 marks.

Reliable information on the design and construction of such craft as tugs, trawlers, &c., is both scarce and scattered. The author of this work, Dr. Sachsenberg, has consequently prepared a volume which will go a long way towards satisfying this need, so far as Germany is concerned. Part I is concerned with various classes of river vessels such as paddle and screw steamers, barges, freight steamers, and also various classes of harbour and sea-going tugs and fishing vessels. The question of strength and general design of river vessels is first dealt with, after which each particular type is examined in considerable and adequate detail. This detail embraces dimensions, weight, resistance, stability, strength, typical midship sections with complete scantlings, details of working parts, accommodation, &c., machinery in considerable detail, paddle wheel (or propeller), boilers, auxiliary machinery, time taken to build (in detail), repairs, &c. The printing of the text and the presentation of the diagrams is almost faultless, a fact which greatly increases the utility of the work. Part II, to be issued shortly, will deal with such craft as pleasure, fire and auxiliary vessels. The work is well worth translating into English.

RE-TURNING A RUDDER PINTLE IN DRY DOCK.

An interesting operation performed with the Aid of a Pneumatic Drill.

The task of turning up a rudder pintle which has become worn as a result of long service generally involves the removal of the rudder and taking it to a well-equipped repair shop.

That it is not impossible to do the job in dry dock is shown by the accompanying drawing, which illustrates a very ingenious but simple machine whereby a pintle which had worn approximately $\frac{200}{1000}$ths out of truth was re-turned; being secured to a bracket on the shaft mounted just above the worm wheel.

The feed of the tool is obtained by means of a star-wheel as shown. Since, however, there is only room to give a very small travel of the turning head, this is provided with four grooves to take the cutting tool, the distance between each groove being slightly less than the maximum travel of the turning head.

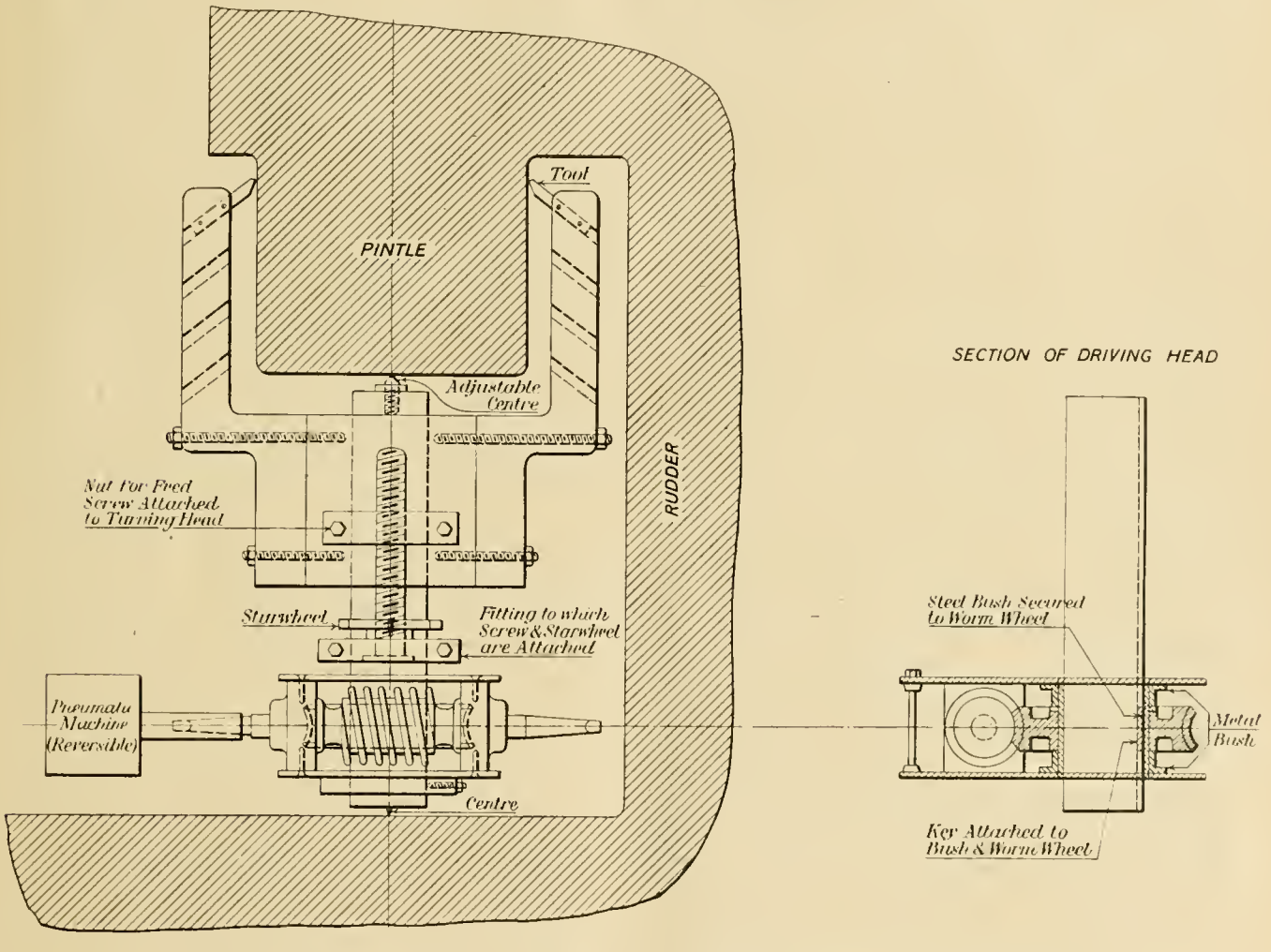


Diagram showing arrangement of Machine for Turning Rudder Pintle in Dry Dock.

The only source of power required was an ordinary pneumatic drill provided with a reversing motion.

The rudder was lifted and placed in the bottom of the dry dock, the temporary cutting machine being arranged below the pintle centre as shown in the diagram. A shaft provided with an adjustable centre and carrying at the bottom a worm wheel is mounted between the centre of the pintle and the body of the rudder. This shaft is driven by a worm which fits into the driving head of the pneumatic machine in the same way as the ordinary Morse taper drill. Secured to the shaft is the turning head which, while rotating with the shaft, is free to slide up or down on a feather key. The feed mechanism consists of an ordinary nut bolted on the turning head in which is a screw, the bottom of the screw

As soon as the cut has been taken with the tool in, say, the lowest groove, the turning head is brought back to its lowest position and the tool inserted in the next groove. The process is then repeated until a cut is taken for the entire length of the pintle.

It was found that the apparatus worked very well, making a very true and smooth job.

LIVERPOOL MARINE ENGINEERS' AND NAVAL ARCHITECTS' DINNER.—Mr. W. L. Roxburgh presided over the 18th Annual Dinner of the Liverpool Marine Engineers and Naval Architects on December 10, and proposed "The Shipping Trade of Liverpool." The improving condition of the coal trade was, he said, one of the brightest gleams in the industrial outlook, and if it continued, it would increase shipping and stimulate manufacture.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.—I.

By E. V. TELFER, B.Sc.

The necessity to secure ample transverse initial stability in a vessel about to be designed has engaged the increasing attention of naval architects almost for the last 70 or 80 years. With the advance of naval architecture and the increase of reliable data at the disposal of designers, the work involved in the problem has been greatly simplified. This simplification is due, not, as is so often the case in pure science, to modifications in the fundamental theory, but to the formation of approximate formulæ based either on sound first principles or upon complete practical data.

In this article the past progress in the subject will be reviewed

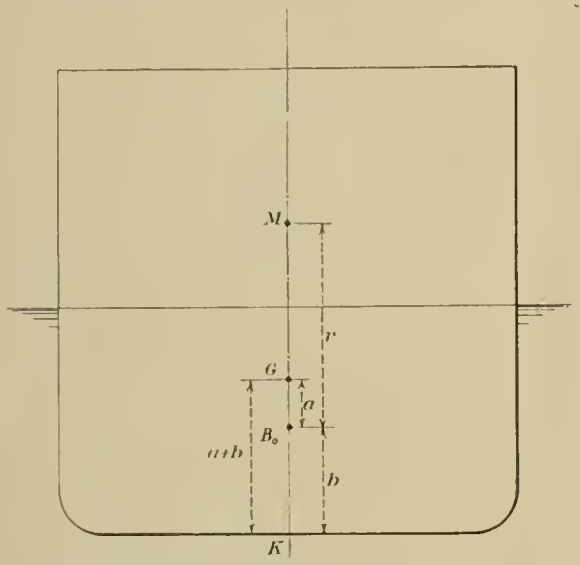


Fig. 1.—Diagram showing the Transverse Metacentric Height (GM) of a Vessel.

from a fundamental point of view and the data recast in such a form as, it is hoped, will prove most accessible to designers.

It is usual (see Fig. 1) to consider the metacentric height GM formed of three distinct quantities. These are :—(1) Metacentric radius $B_0M = r$; (2) height of centre of buoyancy above keel $KB_0 = b$; and (3) either the vertical separation of the centres of buoyancy and gravity, *i.e.*, $B_0G = a$, or, which is better and will be used here, the height of the centre of gravity above the keel, *i.e.*, $KG = a + b$. Modifications in any one of these quantities will affect the value of the metacentric height, and it is thus necessary to know their individual variations in terms of the principal dimensions and coefficients of the vessel, when these latter themselves are varied.

Let us consider first the quantity $B_0M = r$, the metacentric radius. As is well known, $B_0M = \frac{I}{V}$, where I is the transverse moment of inertia of the particular water plane, and V the volume in cubic feet of the corresponding displacement of the vessel. For purposes of design, only such terms as length of vessel L, breadth B, draught d, water plane and displacement coefficients, α and δ respectively, can be considered as fundamental variables, and hence the value of r must be deduced in terms of these quantities. The moment of inertia is calculated as represented in the symbolic relation $I = \frac{2}{3}\int_0^L y^3\,dx$, y being, of course, the half-breadth of the water plane for any point x. Now y may be considered to be a function of L, B, x and α, *i.e.*, $y = f\,(L, B, x, \alpha)$, and hence $I = \frac{2}{3}\int_0^L [f\,(L, B, x, \alpha)\ldots]^3\,dx$ which may be written as $f'\,(L, B, \alpha)$.

For water planes of similar form this latter function reduces to $f'\,(\alpha)\ L.\ B^3$.

Further, the volume displacement V can be expressed $V = L.\ B.\ D.\ \delta$. Hence we have : $B_0M = r = \frac{I}{V} = \frac{f'\,(\alpha)\ L.\ B^3}{L\,B\,d\,\delta}$,

i.e., $B_0M = \frac{f'\,(\alpha)}{\delta} \cdot \frac{B^2}{d}$ .....(1).

This equation (1) must necessarily form the basis of all approximate formulæ for B_0M. The value of $f'\,(\alpha)$ has generally been determined from an analysis of actual form data. Normand, in his "Formules Approximatives" in 1863, deduced an equation similar to (1) and then obtained $f'\,(\alpha)$

TABLE I.

Investigator or Method.	Inertia Coefficient $f'\,(\alpha)$	Basis.	Reference.
Normand	$\cdot 008 + \cdot 0745$	Warship Data	"Formules approx. de Construction navale." 1863.
"Parabolic"	$\frac{\alpha^3}{2\,(\alpha+1)\,(2\,\alpha+1)}$	Analysis	Johow-Foerster Hilfsbuch für den Schiffbau. 1920, p. 472.
Abell	$\alpha\,(\cdot 2\alpha + \cdot 1)^2$	Warship Data	T.I.N.A., Vol. 50, p. 247.
Luke	$\alpha\,(\cdot 17\,\alpha + \cdot 13)^2$	Merchant Ship Data	T.I.N.A., Vol. 50, p. 256.
Hovgaard	$\cdot 0106\,\alpha + \cdot 0727\alpha^2$	Warship Data	Gen. Design Warships, 1920, p. 96.
"Straight Line"	$\frac{3\,\alpha - 1}{25}$	Merchant Ship Data	—

as above. Niels Olsen and Niels Ornell, amongst others, in the *Schiffbau*, Vols. 8 and 19, have shown, on the assumption that the ship's water planes are parabolas of the n^{th} order, that n must equal $\frac{\alpha}{1-\alpha}$, and, further, that $f'\,(\alpha)$ may be expressed as $f'\,(\alpha) = \frac{\alpha^3}{2\,(\alpha+1)\,(2\,\alpha+1)}$. This parabolic method, as it may be called, is quite reasonable for full forms, but for finer forms, where for a given α the area is concentrated amidships and a more sinusoidal form produced, the above value for $f'\,(\alpha)$ will undoubtedly be too small. The limiting values of $f'\,(\alpha)$ for the range $\alpha = \cdot 50 \sim 1 \cdot 0$ will, of course, be those of a triangle and a rectangle respectively, *i.e.*, $\frac{1}{48}$ and $\frac{1}{12}$. These values, it may be noted, are also given by the parabolic formula. *We may state,*

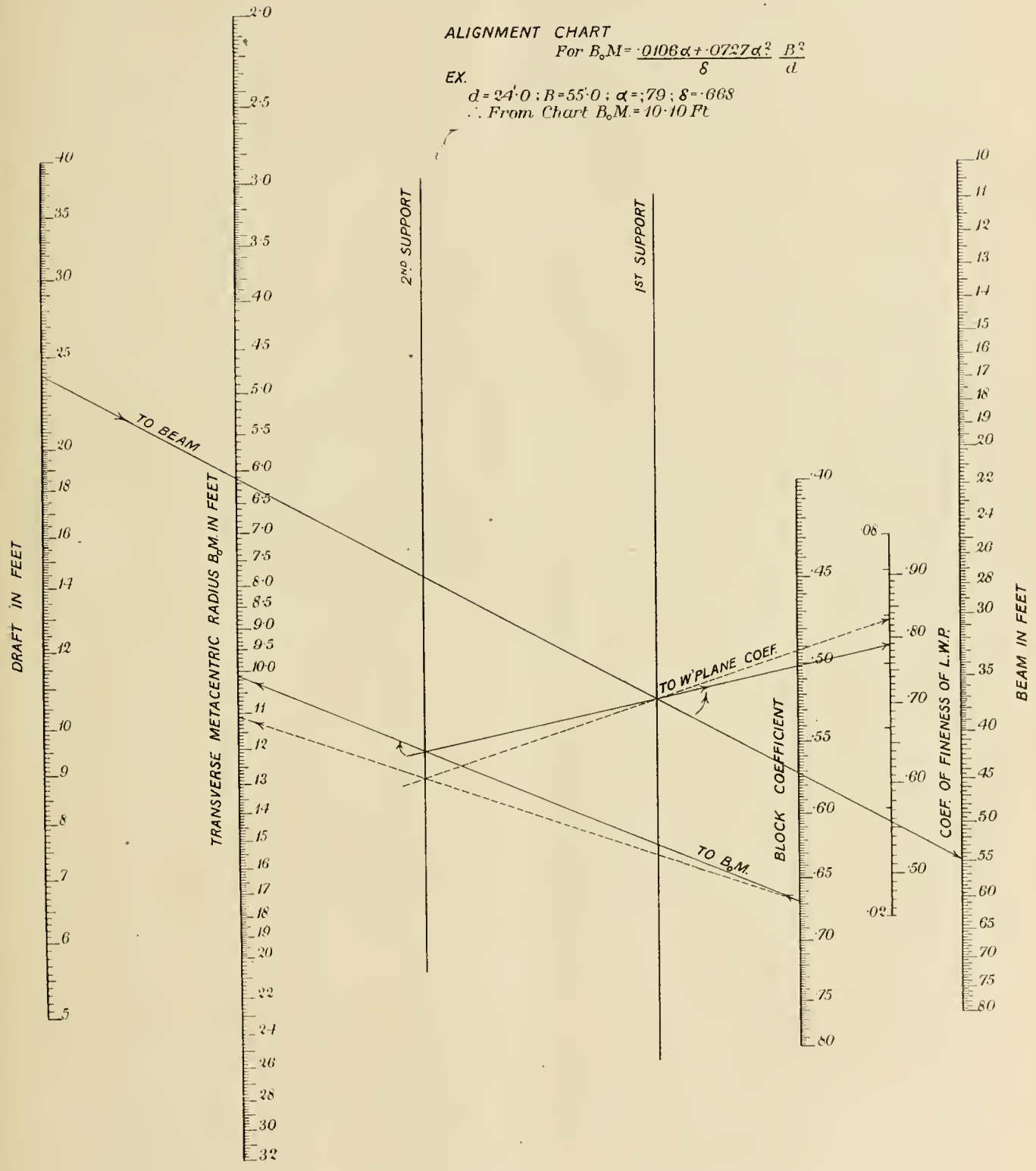

ALIGNMENT CHART
For $B_oM = \frac{\cdot 0106\alpha + \cdot 0727\alpha^2}{\delta} \frac{B^2}{d}$
EX.
$d = 24'0$; $B = 55'0$; $\alpha = ;79$; $\delta = \cdot 668$
$\therefore$ From Chart $B_oM = 10 \cdot 10$ Ft
DRAFT IN FEET
TRANSVERSE METACENTRIC RADIUS B_oM IN FEET
2ND SUPPORT
1ST SUPPORT
BLOCK COEFFICIENT
COEF. OF FINENESS OF L.W.P.
BEAM IN FEET
TO BEAM
TO W'PLANE COEF.
TO B_oM.

Fig. 2.—Alignment Chart for Determining Metacentric Radius.

then, that any formula suggested must satisfy these limits, i.e., *when* $\alpha = 1{\cdot}0$, $f'(\alpha)$ *must equal* ·0833, *and when* $\alpha =$ ·50, $f'(\alpha)$ *must be greater than* ·02083.

In the table on page 6, the value of $f'(\alpha)$ found by various investigators is given, together with the basis used and the source of information.

The values of $f'(\alpha)$ are also plotted in Fig. 3 on a base of α.

Referring to Fig. 3, a critical examination of the methods may be made. The Normand seems to give rather high results for the finer forms, but it has the correct upper limit and will, therefore, be almost correct for fuller forms. The parabolic, as we have seen, gives too low results for the fine forms, but is probably correct for the fuller forms. The Abell gives too low a result for the fine forms, is approximately correct for medium forms, has not correct upper limit, and hence is probably too high for the fuller forms. The Luke seems to be about correct for the finer and medium forms, but, like the Abell, gives too high a result for the fuller forms. The Hovgaard (which is the most modern) would seem to be the one most probably correct throughout its whole range, satisfying, as it does, both limiting conditions. The Straight Line is probably too small for forms of extreme fineness and fullness, but is probably correct for medium forms.

Of the foregoing formulæ two can be recommended — the Hovgaard, because of its general accuracy, and the Straight Line (for medium forms) because of its simplicity in numerical calculation.

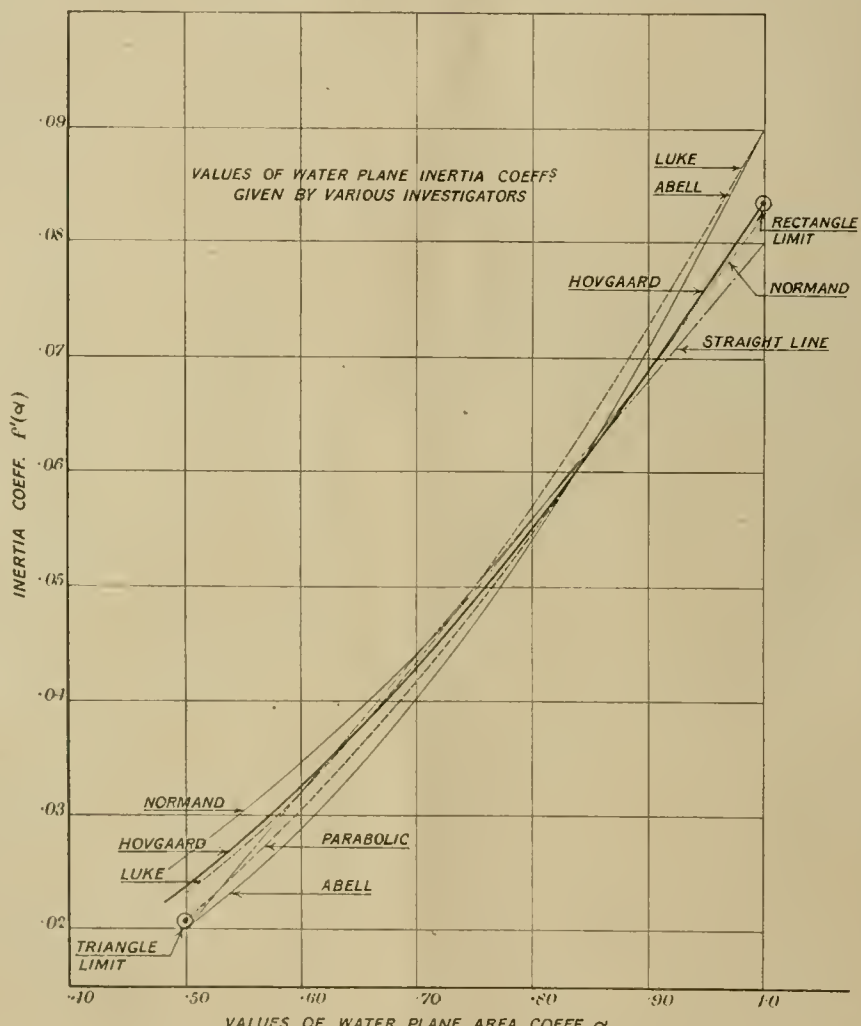


Fig. 3.—Values of Water Plane Inertia Coefficients.

In general design work, where a type calculation has to be repeated so many times, it should be one of the canons of a designer's policy that the calculation should be done once and for all, and so eliminate much labour and chance of inaccuracy. The alignment chart offers to the designer this opportunity, and to complete this section of the subject the Hovgaard equation—

$$B_0M = \frac{\cdot 0106\ \alpha + \cdot 0727\ \alpha^2}{\delta} \cdot \frac{B^2}{d}$$

will be expressed in this form. This is shown in Fig. 2, and a little explanation as to its construction is perhaps necessary. The chart is first prepared by the usual methods to represent the equation—

$$B_0M = \frac{f'(\alpha)}{\delta} \cdot \frac{B^2}{d},$$

and hence contains five variables, one of which, $f'(\alpha)$ (as seen from Fig. 3), ranges from ·020 to ·083. This $f'(\alpha)$ line is subdivided in the usual way and then finally, instead of the $f'(\alpha)$ values being indicated thereon, the scale is converted to read only the corresponding α values. Actually in Fig. 2 these values of $f'(\alpha)$ are left in to enable any other $f'(\alpha) \sim \alpha$ correlation scale to be constructed. For example, where a particular shipyard builds a more or less standard type of ship, the actual values of $f'(\alpha)$ for this type may be taken, and after plotting on a base of α, as in Fig. 3, the corresponding line in the alignment chart may be correlated.

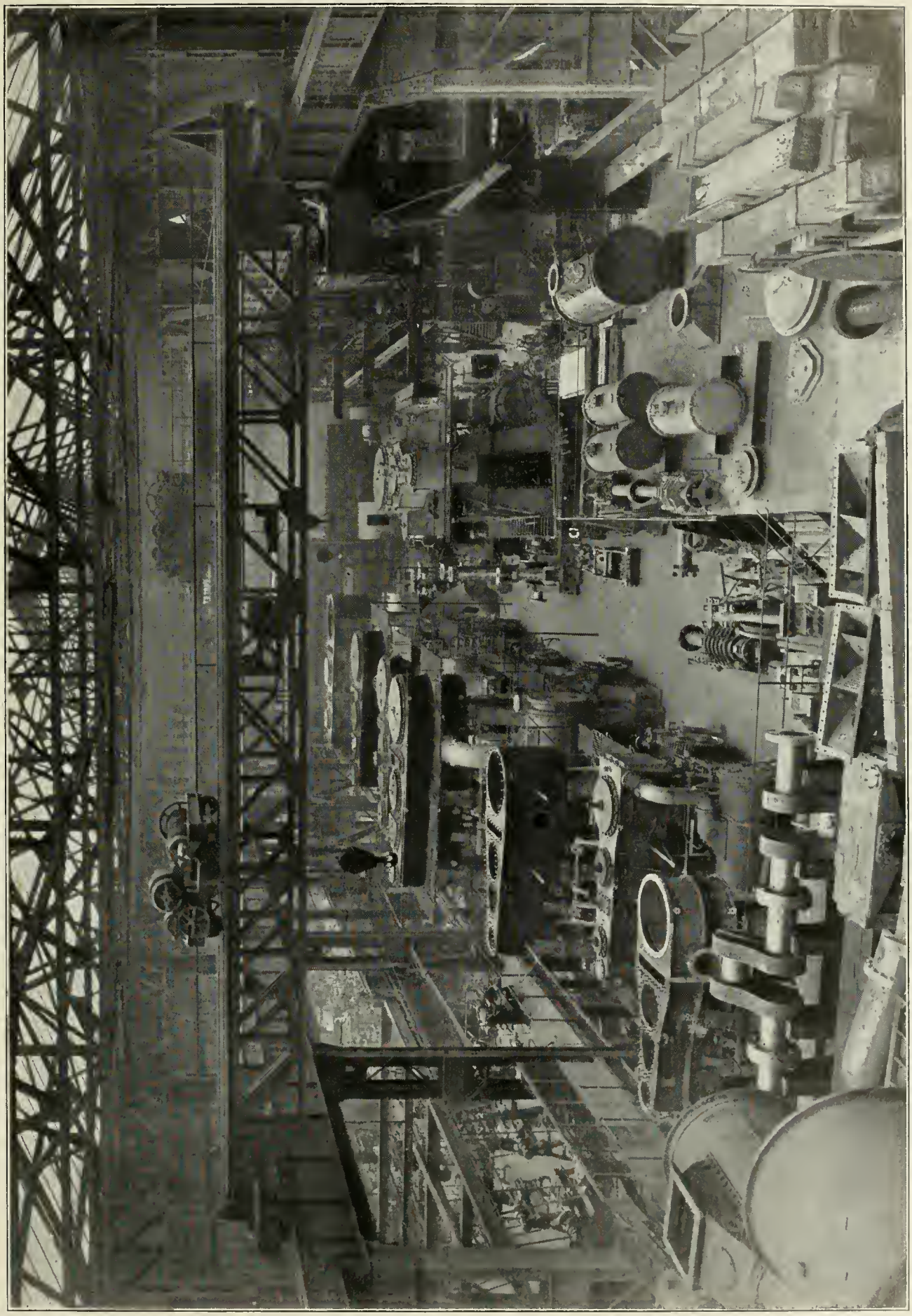
In order to illustrate the use of the chart an example is shown on it. As indicated by the arrows: First, the draught is joined to the beam; next, the water plane coefficient is joined to, and produced through, the point of intersection of the beam-draught line with the first support line, to cut the second support line. The block coefficient is then joined to this latter point of intersection, and the joining line produced cuts the B_0M line at the required value of B_0M. The example given is that of an intermediate passenger liner, 420 ft. long. The actual B_0M as calculated from the lines was 10·15 ft. The chart gives a value of 10·10 ft., *i.e.*, a very close agreement.

Suppose it is desired to increase the B_0M by 1 ft. by merely filling out the load water plane but still keeping the displacement and overall dimensions the same. Join draught to beam as before; join now B_0M (*i.e.*, in this example, 11·1 ft.) to the block coefficient; produce through support intersections to new value of water plane coefficient; and read off (in this case) ·83. This problem is shown dotted in Fig. 2.

To obtain complete control of the design it is necessary to control all three quantities contributing to the metacentric height. This is absolutely essential for initial upright stability, but when investigating the inclined stability, say, up to 30 deg., the B_0M plays a prominent individual part. This is easily seen from a consideration of the well-known formula—

$$GZ = \text{Sin}\,\theta\left(GM + B_0M\,\frac{\text{Tan}^2\,\theta}{2}\right).$$

However, this point will be further enlarged upon after the other two quantities, *i.e.*, position of centres of gravity and buoyancy, have been dealt with. The latter of these will be dealt with in the next article.



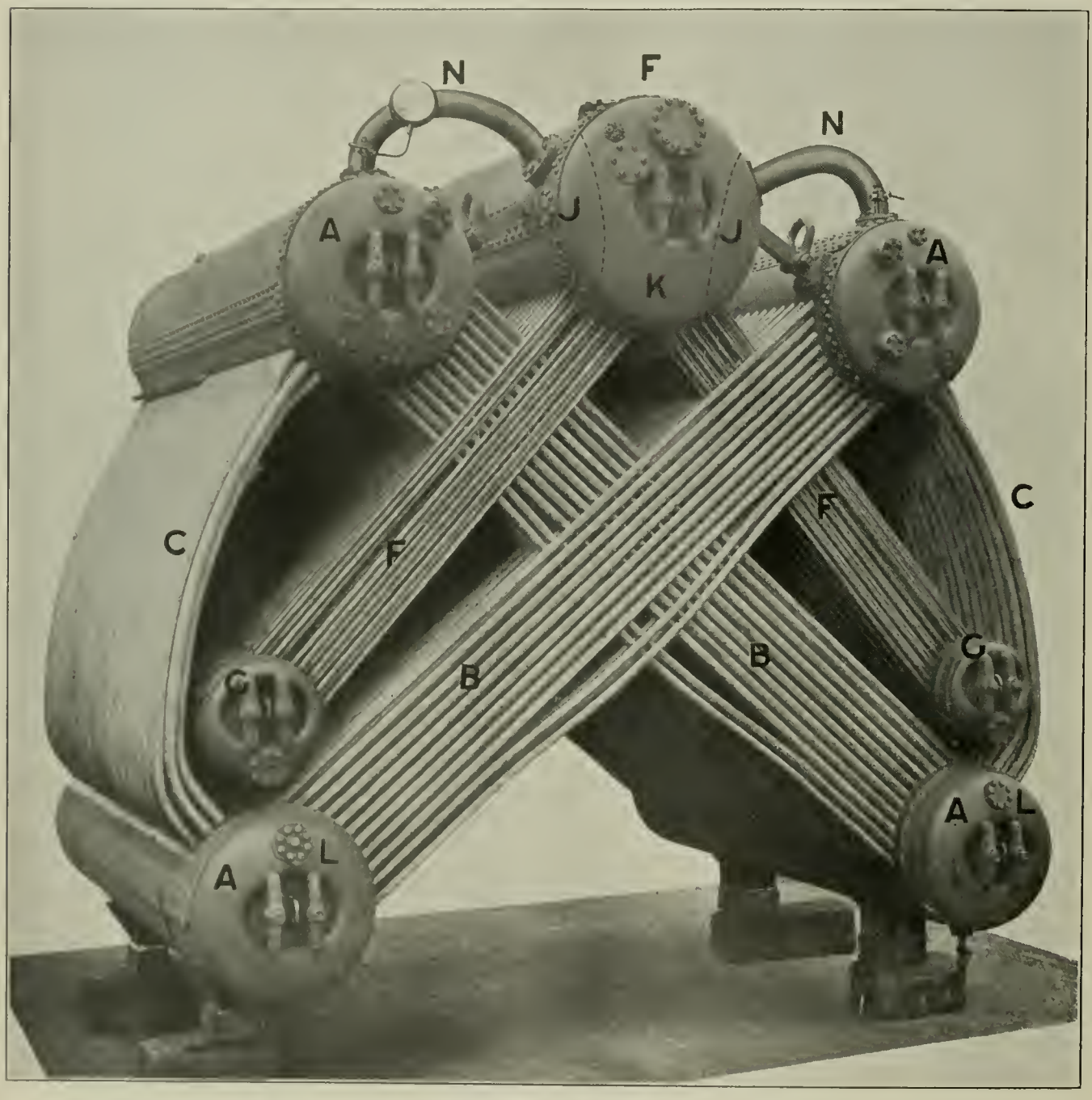
View of Erecting Shop 320′ × 62′ of J. G. Kincaid & Co. Ltd., Greenock, showing Eight Sets of Reciprocating Engines, aggregating 22,500 h.p., being Erected. (See page 32.)

[Photo by] [W. Ralston, Glasgow.

A NEW WATER-TUBE BOILER FOR MERCHANT SHIPS.

Some interesting features of the Hawthorn-Armstrong Patent Boiler.

The increasing use of superheated steam in mercantile vessels propelled by steam turbines or reciprocating machinery has brought about a saving in coal consumption amounting, in some cases which have come to our notice, to as much as 20 per cent. In almost every case this result has been achieved by the adaptation of smoke-tube superheaters to the ordinary cylindrical type of boiler. By the courtesy of R. & W. Hawthorn, Leslie & Co. Limited, we recently inspected at their St. Peter's Works, Newcastle-on-Tyne, a new type of boiler constructed under the Hawthorn-Armstrong Patents. In this boiler an effort has been made to combine in one unit a steam generator suitable for use in merchant ships and to provide a high degree of superheat.



General View of the new Hawthorn-Armstrong Water-Tube Boiler.

The Hawthorn-Armstrong boiler, apart from the superheater elements, possesses all the characteristics of the well-tried Yarrow type, but it is provided with larger water surfaces and steam space than is usual in water-tube boilers of the ordinary type; also the circulation in the evaporating elements

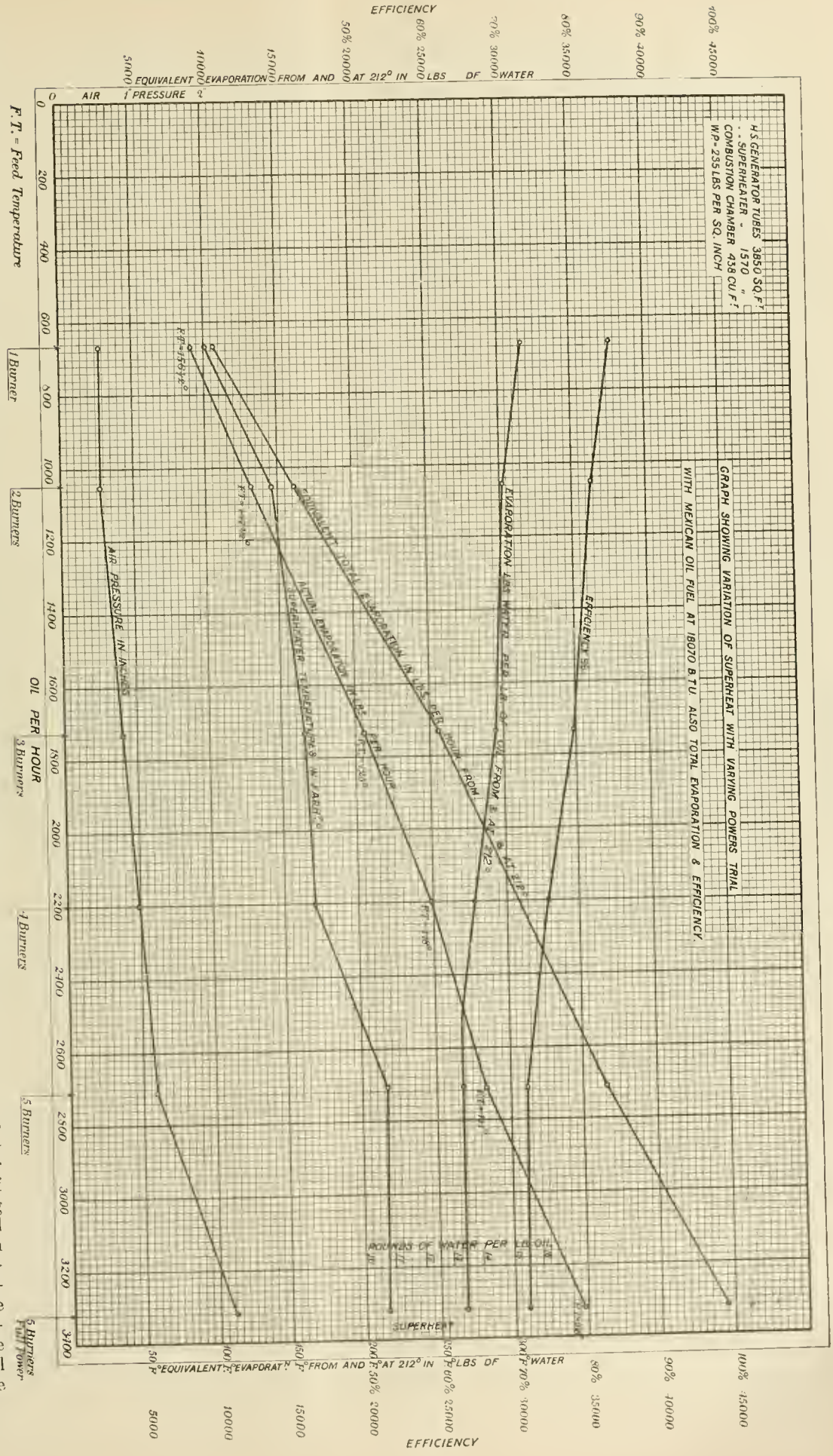
is always continuous and in one direction, the outside tubes forming downcomers and thus establishing a "figure eight" circulation through the crossed tubes at high velocity which scours the insides and prevents deposit even with foul feed water.

An illustration of the boiler is given on page 10, and from this it will be seen that the construction consists of four drums A A A A, which, together with $1\frac{3}{4}$-in. diam. tubes B B, form the evaporating unit connected together crosswise by the tubes interlaced with each other, and three rows of downcomer tubes C C, which form the water wall at the sides.

The combustion chamber is formed under the evaporating tubes B B, and between the two lower water pockets A A.

Incorporated with the evaporating unit are the superheating tubes F F, which are connected to the two lower pockets G G, and one large central steam drum F, the latter being divided into three parts J J K, the middle portion K being the superheat container, and the two wing portions J J forming the passage—via pipes N N—for saturated steam down to the lower pockets G G of the superheater through a portion of the tube and rising up to the central portion of the drum through the remainder of the superheating tubes F F, the steam being superheated in its passage through the small tubes F F. These tubes are 1 in. diam.

(*Contd. on page* 40.)


EFFICIENCY
EQUIVALENT EVAPORATION FROM AND AT 212° IN LBS OF WATER
AIR PRESSURE
H.S. GENERATOR TUBES 3850 SQ. FT.
SUPERHEATER " 1570 " "
COMBUSTION CHAMBER 458 CU. FT.
W.P. = 235 LBS PER SQ. INCH
GRAPH SHOWING VARIATION OF SUPERHEAT WITH VARYING POWERS TRIAL
WITH MEXICAN OIL FUEL AT 18070 B.T.U. ALSO TOTAL EVAPORATION & EFFICIENCY
F.T. = Feed Temperature
1 Burner
2 Burners
3 Burners
4 Burners
5 Burners
5 Burners Full Power
OIL PER HOUR
AIR PRESSURE IN INCHES
EVAPORATION LBS WATER PER LB OF OIL FROM & AT 212°
EFFICIENCY
POUNDS OF WATER PER LB OIL
SUPERHEAT

Hawthorn-Armstrong Boiler, Graph showing Variation of Superheat at varying Powers.

DRILL TESTS OF MARINE BOILERS.—I.

Examination for Corrosion—Removal and Replacement of Tubes—Application to Cylindrical Boilers.

The only absolutely reliable method by means of which the condition of a steam boiler can be ascertained and its life estimated is by the drill test for wear and waste. The vital importance of this operation, both to the marine engineer and to the shipowner, can be easily understood, the efficiency of the boilers playing an all-important part in marine engine economy.

Before describing in detail the method adopted for drill testing each particular type of steam generator, it is as well to understand the general procedure; and it must be borne in mind, that, with the exception, perhaps, of removing cores, the drill test can be carried out by the ship's staff, if the ship is at a foreign port where no repair yard is available. In a ship fitted with cylindrical boilers one boiler in four should be tested, and in a vessel with water-tube boilers, one boiler in each boiler room should be selected for the test. It has been found in practice that these proportions enable a very accurate estimate to be given as regards the life of the remaining boiler shells and tubes. In naval practice it is usual to make a drill test after the boilers have been in use for a period of two years, and then at intervals not exceeding two years. If superheaters are fitted, they are to be tested at the same time as the boilers.

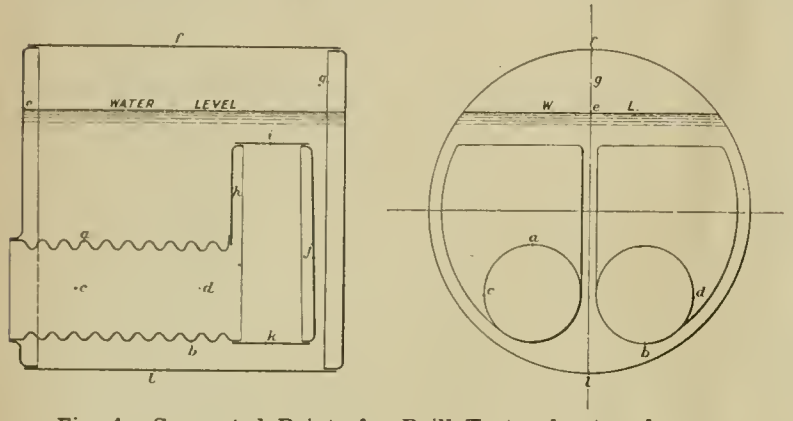


Fig. 1.—Suggested Points for Drill Tests of a two-furnace single-ended cylindrical boiler.

Preliminary Cleaning.

It is essential that the boilers are quite clean, both internally and externally, before the test is carried out; and, as the funnels and uptakes are examined at the same time, they must be cleaned of all soot and deposits. At subsequent drill tests boilers are to be selected which have not been previously tested in this way. When drill testing cylindrical boilers, such tubes are to be drawn as will give a reliable estimate of the whole of the remainder. The furnaces, water space, steam space, and water line must be drilled for thickness; and should the condition of the boiler call for it, additional holes must be drilled. In large tube water-tube boilers the steam space, feed collectors, and mud drums are drilled. Two generator tubes at least must be removed, one being from the top row; and if economisers are fitted, two economiser tubes must also be drawn. In the Yarrow large tube, and in small tube generators, the reservoirs and large tubes, which form part of the boiler proper, are to be drilled for thickness. At least two generating tubes are to be cut out from each side of the furnace, one a fire row tube, and one from the row farthest from the fire, if this operation does not necessitate removing a number of the intermediate tubes. The position of tubes removed and holes drilled will be shown in detail as each particular type of generator is considered. In boilers of the Reed, Yarrow and White-Forster types, cores must be taken from D or non-circular water drums, in the vicinity of the tube and wrapper plates, provided the boilers have been in use for a number of years, or signs of cracks or grooving are apparent in the vicinity of the longitudinal seams. All tubes drawn at the drill test are carefully cleaned in an acid bath, or by any other method, cut in foot lengths, weighed, and their weight compared with the original weight of the tube per foot run. Some of the lengths should be cut longitudinally to ascertain the internal condition and thickness.

Examination for Corrosion.

Before opening out a boiler for drill test the whole boiler must be cleaned externally, including the uptake and funnel. If F.D. fans are fitted with closed stokeholds, a good plan is to close down the particular boiler room in which the boiler under test is situated, and utilise the fans to blow all loose soot and dust out of the funnels. This operation should be repeated after completing the cleaning externally. Funnels and uptakes are particularly liable to corrosion and deterioration, both internally and externally, especially at the junctions; and great care is required when examining these parts for signs of wear and waste. After opening out the boiler, and before starting to clean internally, a very careful and thorough examination must be made of any dirt and deposits found at different parts of the boiler. The condition of the zinc slabs and hangers must be noted, particular care being taken in deciding if any of the slabs are of further use.

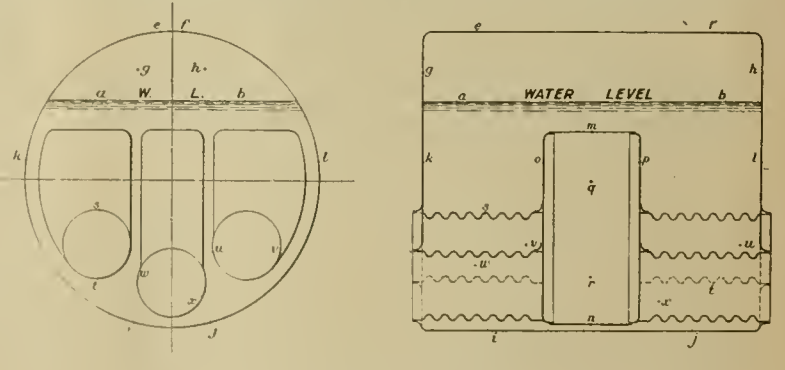


Fig. 2.—Position of Test Holes in a double-ended six-furnace cylindrical boiler.

Should any be replaced, they must first be subjected to severe hammering to remove all loose zinc and deposit.

In water-tube boilers the tubes must be carefully examined for signs of distortion, such distortion usually being found with the rows nearest to the fire; a considerable bend or a bulge in any particular tube indicates the presence of internal deposits or oil, &c., in the feed water. Any such tube must be cut out in addition to those selected for the drill test. The brickwork of boilers under test should be examined for cracks, and a portion of the floor taken up for examination

of the plating underneath. Portions should also be taken down at the backs and sides; and in the case of small tube water-tube boilers, the brickwork at base of tubes in the furnace should be completely removed. In oil-fired boilers fitted with air cones, the cone bricks must be examined and renewed as necessary. All boiler mountings must be examined and, if necessary, refitted, and all doors removed. In water-tube boilers of the large tube type the following parts should also be examined, viz., non-return valves at the bottom of down-take pipes, internal fittings of steam collectors, all automatic float gear and levers, water-gauge mountings, element supports, blow-downs and sediment chambers. In water-tube boilers fitted with a number of small doors, such as the Belleville, a good plan is to have a fitted door, which is used as a gauge. When all the doors are removed for test, the gauge should be tried in all the openings, and if slackness is found, special doors should be made to suit. This method prevents many small leaks, and effects a great saving in feed water.

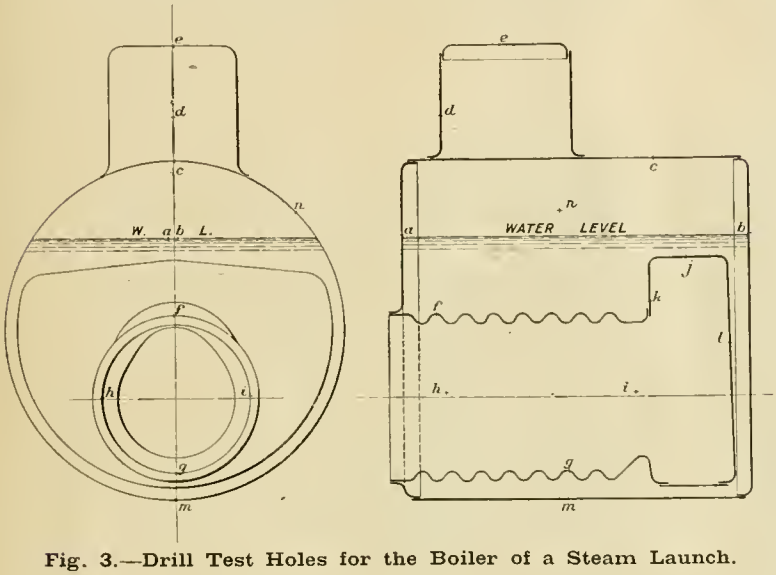


Fig. 3.—Drill Test Holes for the Boiler of a Steam Launch.

Removal and Replacement of Tubes.

Only a few special cases need be mentioned, the removal and replacement of tubes in a cylindrical boiler being a simple operation. To remove a tube from a Yarrow boiler, cut through with a cross-cut chisel close to top and bottom tube plates. Drive out the tin pieces with a shoulder punch, care being taken not to injure the tube plate. To replace a tube, thoroughly clean the ends, place in position, tightly roll and bell mouth both ends. The operation is completed by expanding as necessary. With the Dürr boiler, a special set of tools is provided for the purpose and the removal of a generator tube is carried out as follows. Remove the inner tube and back end door or cap, insert special apparatus in the tube from the front, and withdraw tube. To ease the tube in the cone gently top back end of apparatus. In replacing the tube, the cone surfaces must be thinly coated with black-lead and mineral grease, in order to lessen friction in pressing tube home. The mark stamped on the front of the tube cone must stand exactly at the top. The tubes are forced in, either by means of a screw press, or by hydraulic pressure. In the latter case a pressure of 2,200 to 2,600 lb. per square inch is required. When forcing in, light blows should be given with a wooden hammer. The tubes must be guided into their place in the back tube wall. If, when the tube is in position, there is not more than $\frac{1}{8}$ inch clearance between safety collar and tube plate, the tube must be taken out again and the cone expanded. This expanding is done by the ordinary tube rollers, first putting over the joint a massive steel gauge ring, bored to the size of the standard cone.

Details of Drill Tests of Cylindrical Boilers.

Fig. 1 shows the positions at which it is suggested that drill tests should be made in a two-furnace single-ended boiler. As will be seen, four holes, A, B, C, D, are drilled in the furnaces, one, E, at the water line, G in the steam space, F on the top, L on the bottom in the water space, and H, I, J, K in the combustion chambers. The various positions selected will enable an excellent estimate to be made as to the general condition of the boiler. Tubes must be drawn and cut as previously described. After drilling and gauging, fine-thread plugs must be used for plugging the test holes. Fig. 2 shows the position of test holes in a double-ended six-furnace boiler. Holes are drilled: E, F at top, G, H in steam space (at each end), A, B at water line, K, L, I, J in water space, S, T, U, V, W, X in furnaces, and M, N, O, P, Q, R in combustion chamber. It will be noted in the double-ended boiler the holes are duplicated at each end, and a hole drilled in each furnace in a different position. Should, of course, the boiler shell show any signs of excessive wear at any particular spot after cleaning, a hole should be drilled and plate gauged. It is most important when gauging for thickness after drilling, that all burrs are removed and that the surface round the holes is quite clean. Any rivets which have given trouble should be caulked before the water-pressure test is applied. It is usually found that the rivets in the bottom seam are the first to leak, but in many cases rivets which show just a head at the water-pressure test will take up under steam. Any rivet which will not stand caulking must be renewed.

Smaller Fire-Tube Boilers.

Fig. 3 shows the position of drill test holes for the boiler of a steam launch. Holes are drilled: A, B at water line,

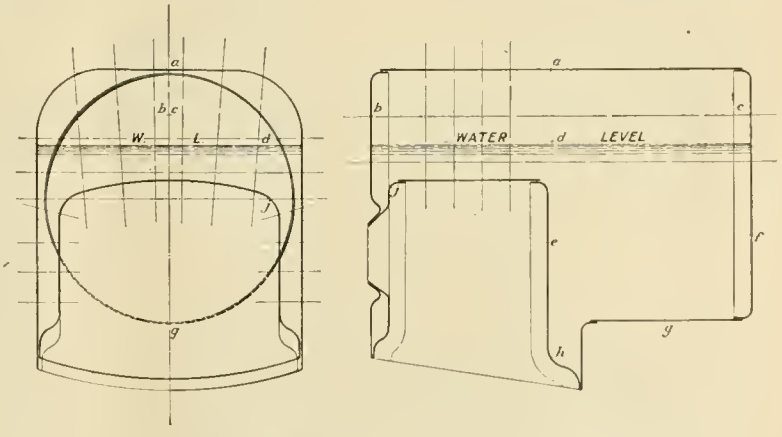
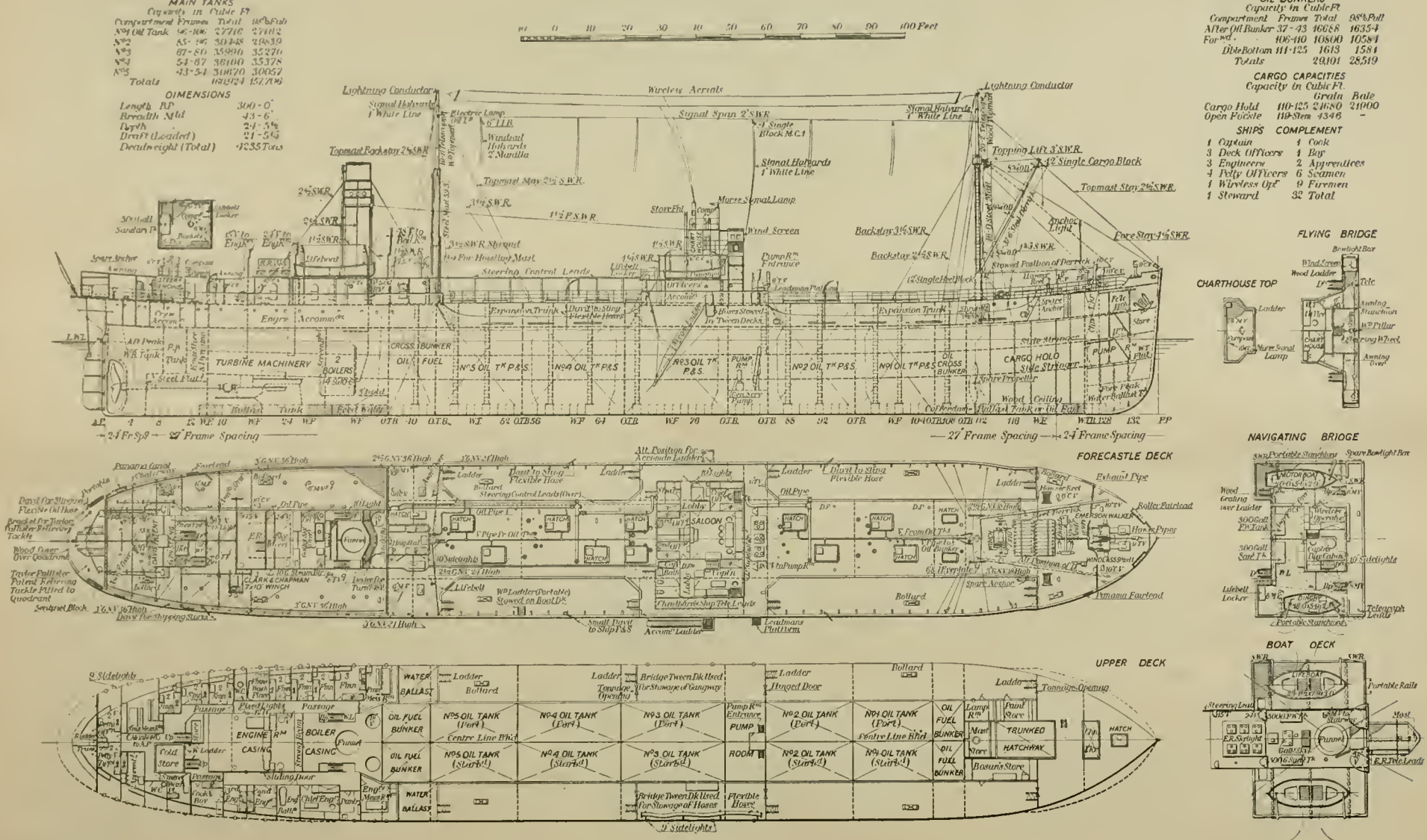


Fig. 4.—Drill Test Holes for the Boiler of a Steam Pinnace.

C, N in steam space, M in water space, D, E in steam dome, F, G, H, I in furnace, and K, J, L in combustion space. It must be borne in mind that the boilers of a steam launch must be treated as regards drill test in all respects as main boilers. Fig. 4 shows the boiler of a steam pinnace of slightly different combustion, this being of the locomotive type. Holes A, B, C are drilled in steam space, D at water line, and E, F, G, H, J in water space. Particular attention must be paid to holes H and J when drilling and plugging; if necessary, the plug must be fitted under the head.

(*To be continued.*)



General Arrangement of Oil Tank Steamer "Sjømand."

OIL TANK STEAMER "SJØMAND."

Built and Engined by John I. Thornycroft & Co. Limited, Southampton, for the Laboremus Co., of Christiania.

The oil-carrying vessel *Sjømand*, general arrangement and other drawings of which are published in this issue, was built by John I. Thornycroft & Co. Limited at their Woolston Works, Southampton, to the order of Aktieselkadet Laboremus, Christiania, under the supervision of Arnesen Christensen & Smith, of Newcastle-on-Tyne.

This vessel has been built to the design of J. I. Thornycroft & Co., and is constructed for the special purpose of carrying petroleum in bulk, the cargo space being subdivided into ten tanks with a total capacity of 160,900 cubic ft. The turbine machinery is placed aft, and the navigating bridge and officers quarters amidships, while the crew and engineers are accommodated in the poop.

SS. "Sjømand." Dining Saloon.

Dimensions.

The vessel has been built to Lloyd's 100 A1 classification, and to Norwegian Board of Trade requirements. The following are the dimensions :—

Length	300 ft.
Breadth	43 ft. 6 in.
Depth	24 ft. 6 in.
Deadweight	4,235 tons.
Draught	21 ft. 5¼ in.
Gross tonnage	2,837 tons.
Net tonnage	1,585 tons.

The *Sjømand* is lighted throughout with electric light and fitted with wireless telegraphy. The masts are arranged to carry strong derricks for lifting heavy loads so that the vessel can be used in connection with the whaling industry if desired. The auxiliary deck machinery consists of two winches 7 in. by 10 in., manufactured by Clarke, Chapman, steam steering gear by John Chambers & Co., and steam windlass by Emerson Walker & Co.

Main Engines.

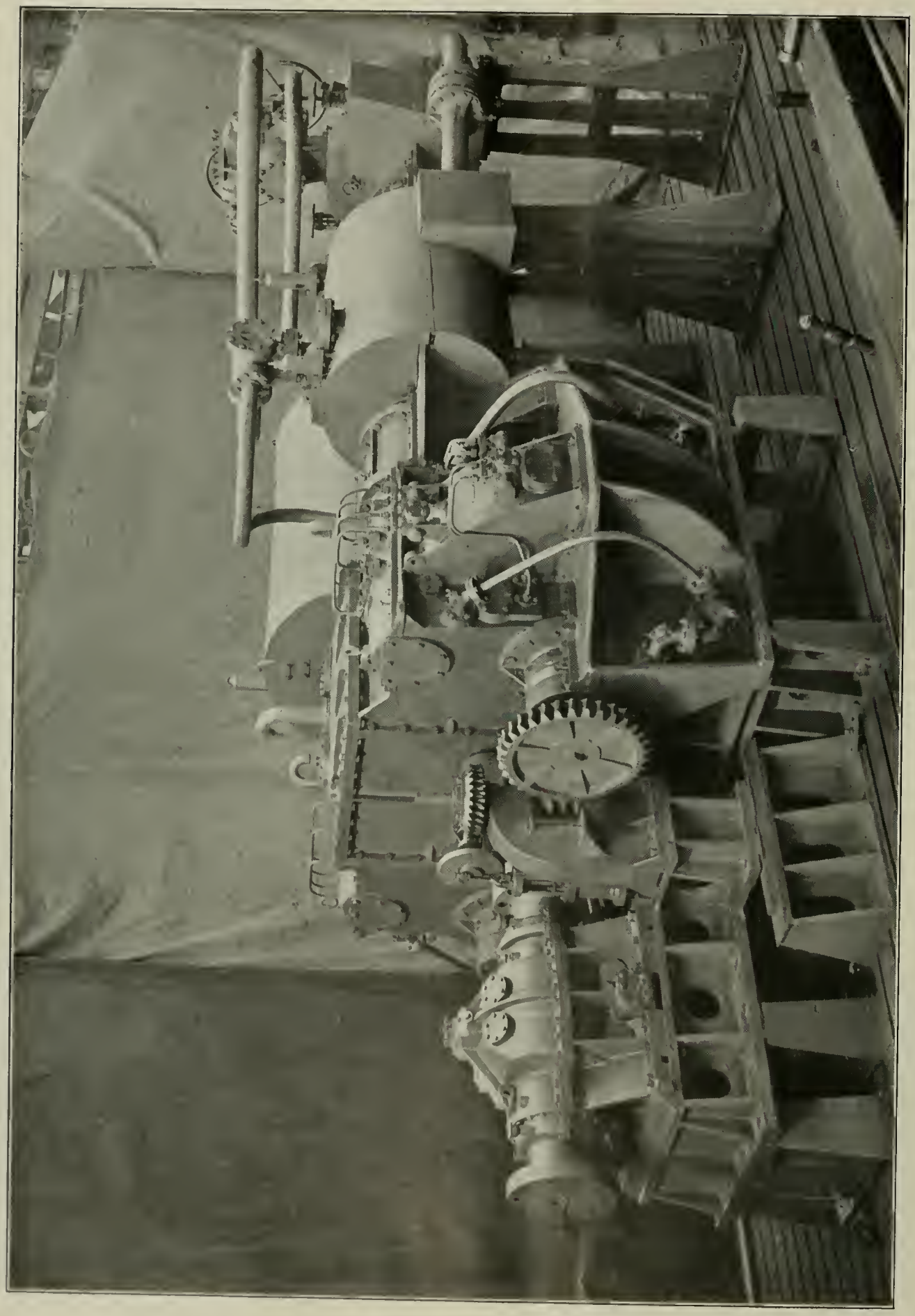
The machinery consists of Brown Curtis turbines driving the main shaft through double reduction gears. The turbines, details of which are given in the plate drawings, were built by J. I. Thornycroft & Co., and consist of H.P. and I.P. ahead and H.P. astern on the starboard pinion shaft, and L.P. ahead and astern on the port pinion shaft, designed to develop 1,550 s.h.p.

With a view to economy superheated steam is used, and to suit this the H.P. cylinder is of cast steel and the diaphragms of phosphor bronze and nickel steel. The blading is of phosphor bronze throughout, combined sections being used. The thrust block is of the Michell type. The piping between turbines is so arranged that either H.P. and I.P. or L.P. turbines can be run independently, so that in the event of a breakdown in the L.P. turbine the exhaust from the I.P. turbine is passed direct through a nozzle to the condenser, or in the case of a breakdown in the H.P. or I.P. turbines direct steam can be admitted to the L.P. turbine. The H.P.

(*Continued on page* 26.)

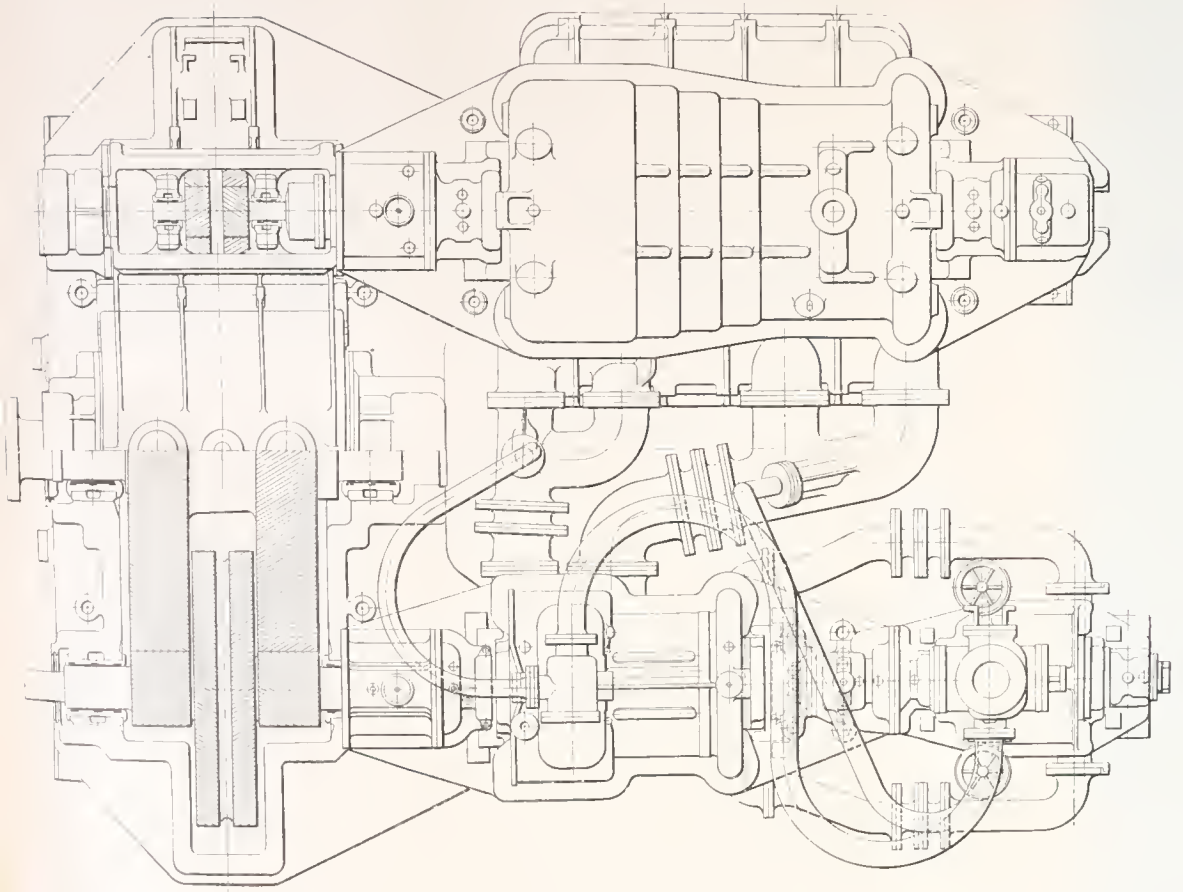
Captain's Cabin.

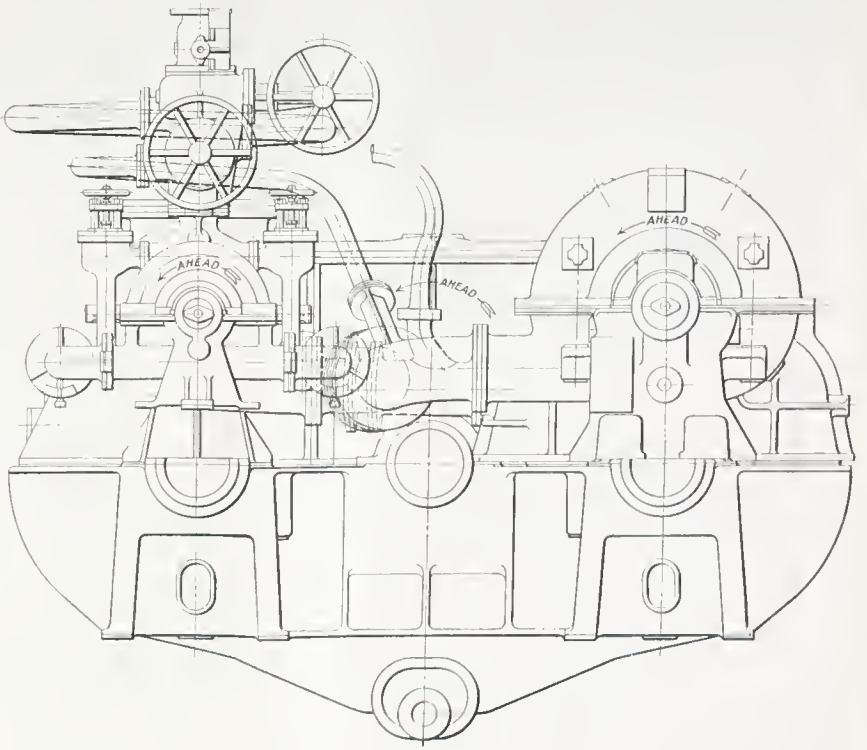
Chief Engineer's Cabin.



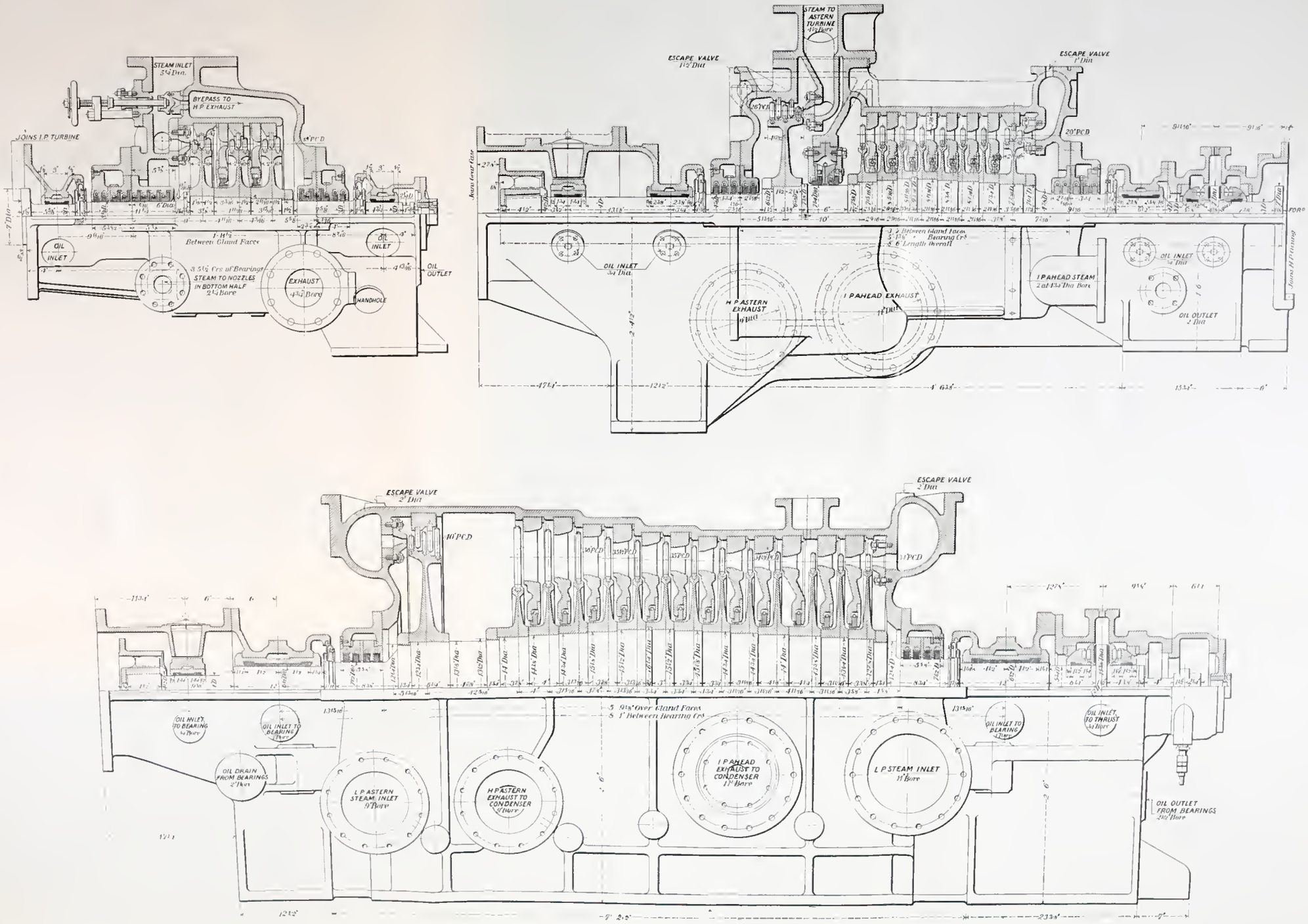
Turbines for the Oil Tanker "Sjømand," erected in the Shops of John I. Thornycroft & Co. Ltd., at Southampton.

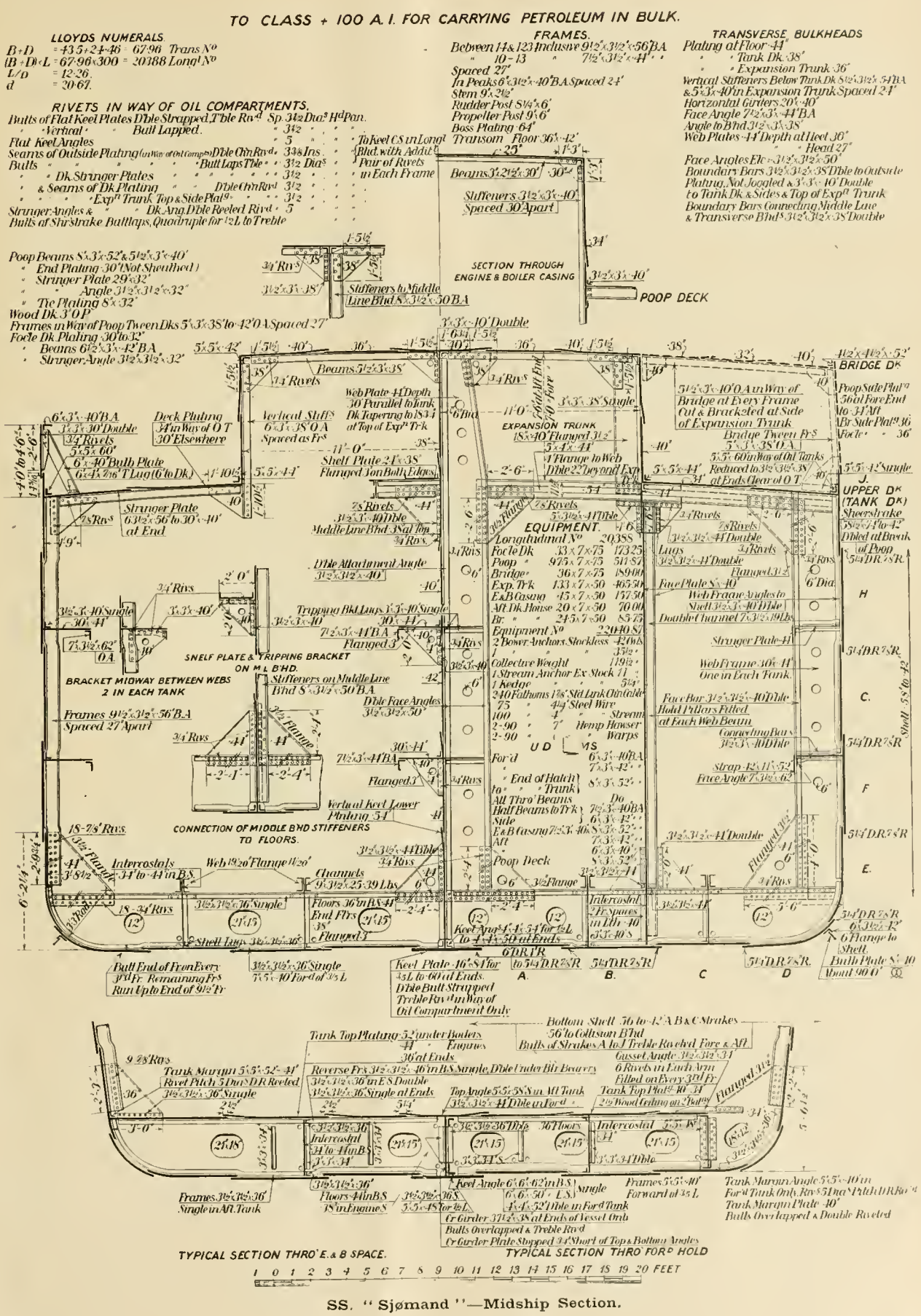
GENERAL ARRANGEMENT OF DOUBLE REDUCTION GEARED TURBINE ENGINES OF THE "SJOMAND."



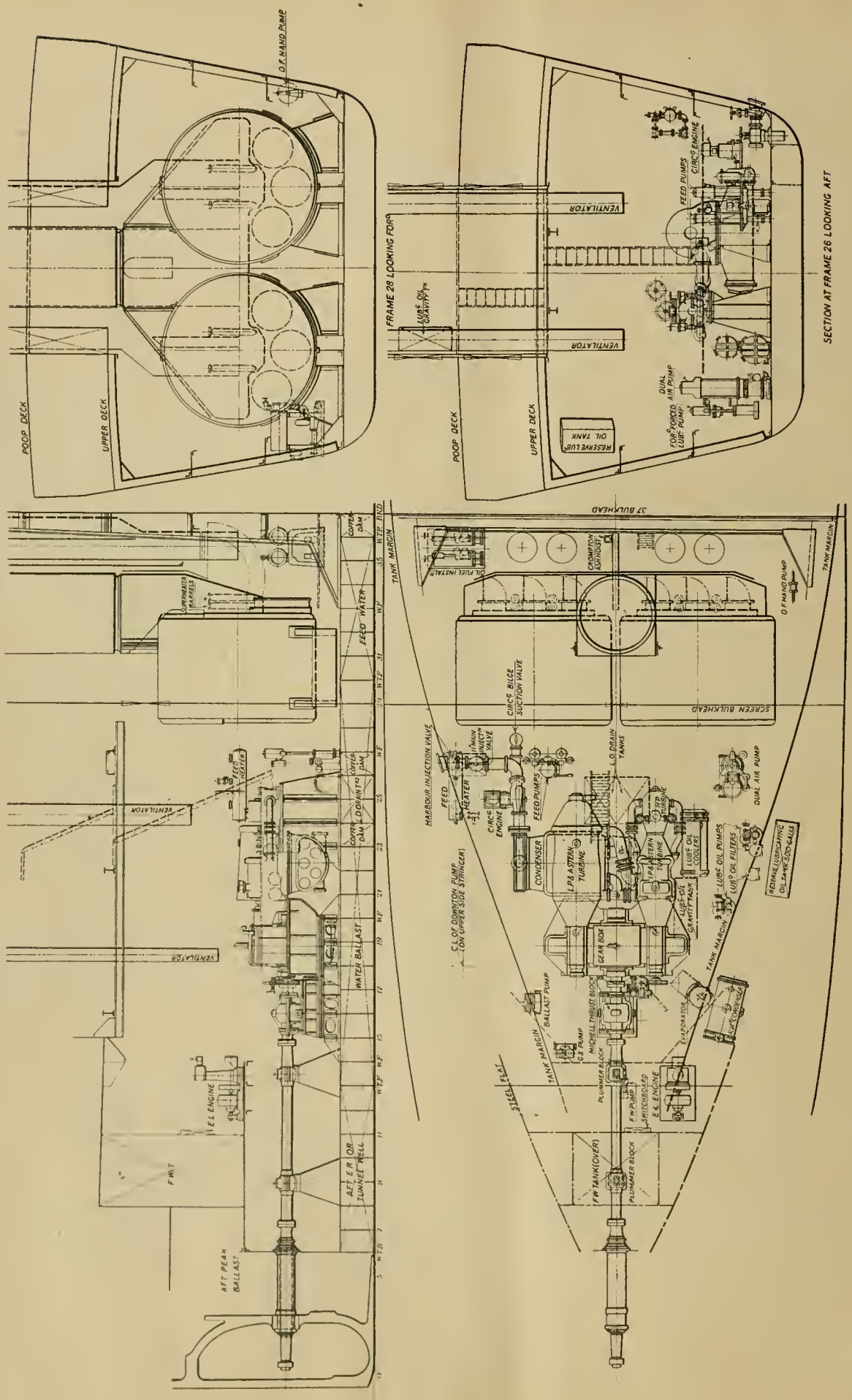


SECTIONAL VIEWS OF THE GEARED TURBINES OF THE "SJOMAND," CONSTRUCTED BY JOHN I. THORNYCROFT & CO. LTD., SOUTHAMPTON.




TO CLASS + 100 A.1. FOR CARRYING PETROLEUM IN BULK.
LLOYDS NUMERALS.
B+D = 43.5+24·46 = 67·96 Trans No
(B+D)×L = 67·96×300 = 20388 Long No
L/D = 12·26.
d = 20·67.
RIVETS IN WAY OF OIL COMPARTMENTS.
FRAMES.
TRANSVERSE BULKHEADS
SECTION THROUGH ENGINE & BOILER CASING
POOP DECK
BRIDGE DK
UPPER DK (TANK DK)
EQUIPMENT.
EXPANSION TRUNK
SNELF PLATE & TRIPPING BRACKET ON M L BHD.
BRACKET MIDWAY BETWEEN WEBS 2 IN EACH TANK
CONNECTION OF MIDDLE BHD STIFFENERS TO FLOORS.
TYPICAL SECTION THRO' E. & B SPACE.
TYPICAL SECTION THRO' FOR'D HOLD
1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 FEET

SS. "Sjømand"—Midship Section.



Double Reduction Geared Turbine-Driven Oil Tanker "Sjømand"—General Arrangement of Machinery Space.

PROPELLERS FOR OIL-ENGINED SHIPS.

Outstanding Problems—Performances on Service—Analysis of Results.

In the annual report of Lloyd's Register of Shipping, recently issued, reference is made to the large number of twin-screw as compared with single-screw vessels fitted with oil engines. In ships above 1,000 tons the number of twin-screw Diesel engined was 120 as compared with 28 single-screw vessels, whilst there was fitted oil engines of other types in 40 twin- and 4 single-screw ships. The principal reason for this predominance is that oil engines are generally made with a short stroke and run at a high rate of revolution, a condition which makes it more efficient to use twin-screw propellers of smaller diameter than would be possible for single screws working at the same power. The convenience of having single screws has led, however, to certain types of oil engines being made with long strokes, so as to reduce the number of revolutions and so make possible higher propeller efficiencies.

An illuminating paper on " The Comparison between Single- and Twin-screw Motor Ships " was recently read at Gothenburg, Sweden, by Mr. H. Blache, a director of Burmeister & Wain, Copenhagen. In this paper many points of interest in connection with oil-engined vessels were referred to, but

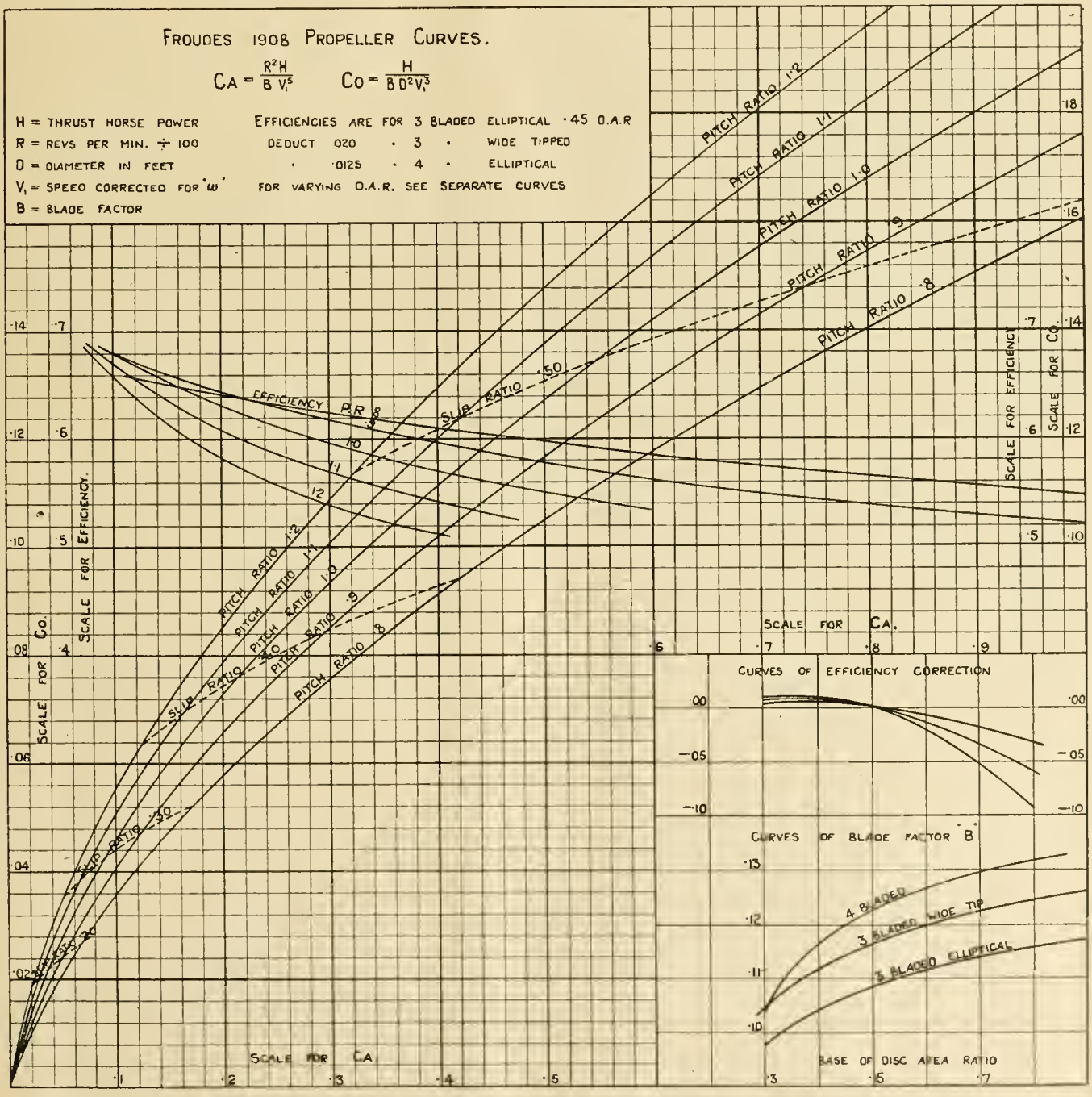

FROUDES 1908 PROPELLER CURVES.
$C_A = \frac{R^2 H}{B V_1^5}$ $C_O = \frac{H}{B D^2 V_1^3}$
H = THRUST HORSE POWER
R = REVS PER MIN. ÷ 100
D = DIAMETER IN FEET
V_1 = SPEED CORRECTED FOR 'ω'
B = BLADE FACTOR
EFFICIENCIES ARE FOR 3 BLADED ELLIPTICAL ·45 D.A.R
DEDUCT 020 · 3 · WIDE TIPPED
· 0125 · 4 · ELLIPTICAL
FOR VARYING D.A.R. SEE SEPARATE CURVES
PITCH RATIO 1·2
PITCH RATIO 1·1
PITCH RATIO 1·0
PITCH RATIO ·9
PITCH RATIO ·8
EFFICIENCY
SLIP RATIO ·50
SLIP RATIO ·40
SLIP RATIO ·30
SLIP RATIO ·20
SCALE FOR EFFICIENCY
SCALE FOR Co.
SCALE FOR CA.
CURVES OF EFFICIENCY CORRECTION
CURVES OF BLADE FACTOR B
4 BLADED
3 BLADED WIDE TIP
3 BLADED ELLIPTICAL
BASE OF DISC AREA RATIO

Fig. 1.—Froude's 1908 Propeller Curves.

to one phase only of the general question of Diesel engined ship propulsion do we wish to refer in the present article.

Mr. Blache said that just as the relation between length, beam and depth characterises the hull of a vessel, so is the ratio between the cylinder diameter and the length of stroke the deciding dimensions for a piston engine. When starting the construction of marine Diesel engines his firm fixed the ratio at 1·33, based on the experience gained by the manufacture of stationary Diesel engines. Thus the motor ship *Selandia* had a cylinder diameter of 540 mm. with a stroke of 740 mm., and the motor ship *Suecia*, 500 mm. cylinder diameter with a stroke of 660 mm., giving a ratio of about $1\frac{1}{3}$. With this ratio, and due regard to the speed allowed through the inlet and exhaust valves normally fitted in an engine of this description, the most suitable number of revolutions per minute will be 140 to 150. This number of revolutions, whilst desirable from the point of view of engine efficiency, is much higher than that which is associated with high propeller efficiency. Great difficulty therefore arises as to how to obtain good engine and also good propeller efficiencies. In the experience of Mr. Blache's firm this can best be obtained by the adoption of twin screws, and he compared the results of the twin-screw motor ship *Suecia* with those of the single-screw steamer *Prinsessan Ingeborg*, which results indicated that the propulsive efficiency obtained by the twin-screw motor ship equalled that given by the single-screw steamer.

A paper on the "Performance on Service of the Motor Ship *Suecia*" was given by Mr. Knudsen, also of Burmeister & Wain, to the Institution of Naval Architects in 1913. In the discussion which followed the reading of this paper, Mr. E. Hall-Brown gave some particulars of the performances of the single-screw motor ship *Eavestone*, and the writer now proposes to analyse the trial results of these three vessels, viz., the *Suecia*, the *Eavestone* and the *Prinsessan Ingeborg*, and so attempt to arrive at values of the various factors which contributed to the results given. Values of effective horse-powers have been calculated for each of these vessels, the actual E.H.P.'s being unknown. The particulars of the ships, their propellers and results, are as follows :—

——	*Suecia.*	*Eavestone.*		*Prinsessan Ingeborg.*
Length in feet	362	276		360
Breadth in feet	51·25	40·5		48·75
Draught, medium, in feet	23·1	17·79		21·83
Block coefficient	0·78	0·77		0·78
Displacement in tons	9,625	4,360		8,660
Deadweight in tons	6,500	—		5,895
Number of screws	Twin	Single		Single
Type of engine	Diesel	Diesel		Reciprocating
Indicated horse-power	2,140	1,075 sea	1,075*	2,050
Shaft horse-power (estimated)	1,710	—	—	1,750
Propeller—				
Diameter in feet	10·0	12·25	—	17·5
Pitch in feet	8·16	10·62	—	17·5
Surface (expanded)	—	64	—	—
No. of revolutions per minute	149	90	93·5	67·5
Speed in knots	11·0	8·75	9·38	11·0
Effective horse-power (estimated)	1,150	325	415	1,080
Propulsive efficiency $\frac{E.H.P.}{I.H.P.}$	0·537	0·302	387	0·527
Apparent slip per cent. $= \frac{Vp - V}{Vp}$	9·16	7·11	4·0	5·66

* Trial (assumed).

In the above figures it is shown that the twin-screw motor ship *Suecia* had a slightly higher propulsive efficiency than has the single-screw steamer *Prinsessan Ingeborg*, which must be considered satisfactory, especially in view of the very low efficiency shown by the *Eavestone*. This has been obtained, as Mr. Blache points out, by the adoption of twin screws, and so limiting the amount of power being put through relatively small propellers. Mr. Hall-Brown said that the screw fitted in the first instance on the *Eavestone* was designed for 105 to 110 revolutions, and the speed obtained with that propeller was very unsatisfactory in relation to the power the engine was developing. The reason for this may be seen

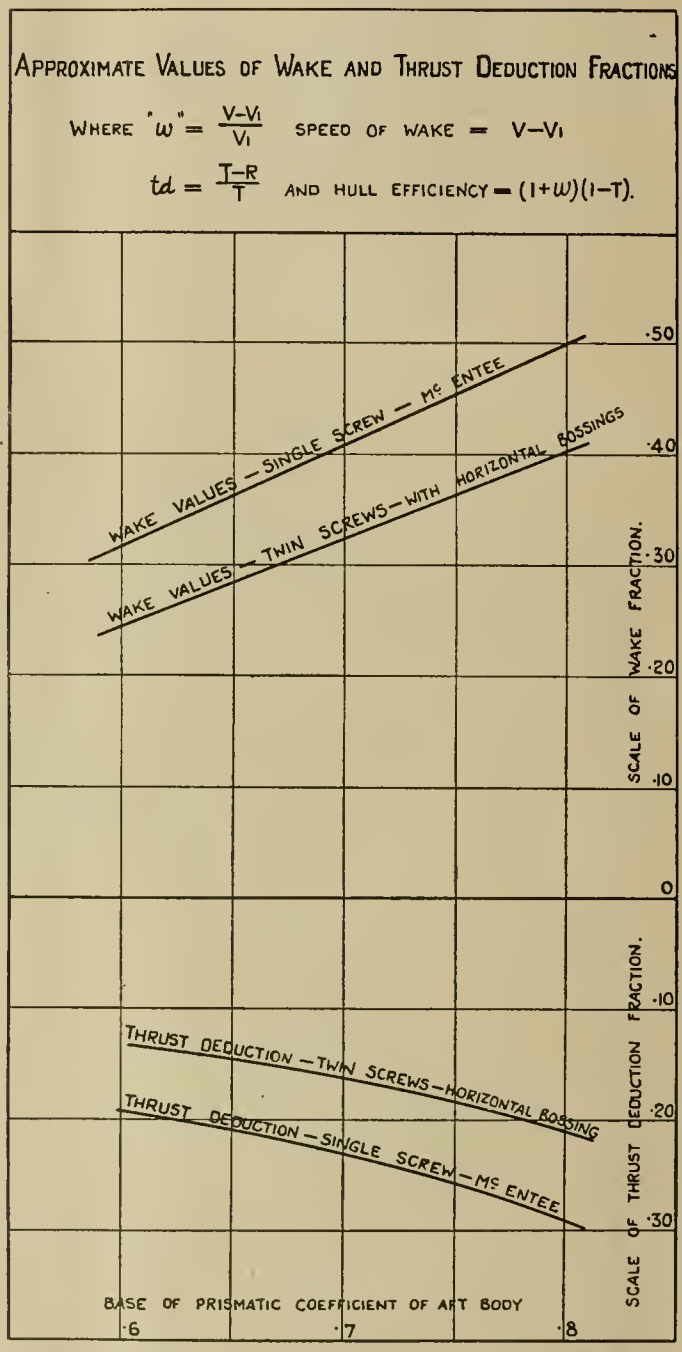


Fig. 2.—Approximate Values of Wake & Thrust Deduction Fractions.

—in part—if the case is worked out according to the formula given in Fig. 1 (Froude's 1908 propeller curves).

It is possible also that the effective horse-power calculated for the *Eavestone* may be lower than the actual. In the figures given later in the analysis it will be seen that the engine efficiency arrived at by analysis is very low. Were the E.H.P. increased the propulsive efficiency would show up better, but, on the other hand, it would indicate that the form given to the vessel had not been quite satisfactory.

Analysis of Results.

The method adopted in this analysis follows on lines similar to those successfully used by Mr. Frodsham Holt in his analysis of the trial results of the *Mackay* (T.I.N.A., 1920). In that vessel the E.H.P. at 32·4 knots was 21,440, and the thrust given by the propellers at this speed was 115·5 tons. The resistance of the ship equalled 96·2 tons, the augment to resistance being therefore 19·3 tons, the thrust deduction factor being $\frac{115\cdot5 - 96\cdot2}{115\cdot5} = \cdot167$

Resistance in tons $= \frac{\text{E.H.P.} \times \cdot1455}{\text{V}}$.

calculated; this is modified so as to arrive at the thrust necessary for self-propulsion.

The effective horse-power of the vessels analysed have been calculated, and Fig. 3 has been prepared so as to afford a ready approximation to the E.H.P.'s of full cargo ships and also to the resistance in tons proper to these E.H.P.'s and speeds.

In the table of analysis it will be seen that an addition of 13 per cent. has been made to the E.H.P. resistance in the case of the twin-screw *Suecia* and of 3 per cent. on the single-screw vessels, this allowance having been made for bossings, rudder and bilge keels in the one case, and rudder and bilge keels only in the single-screw ships.

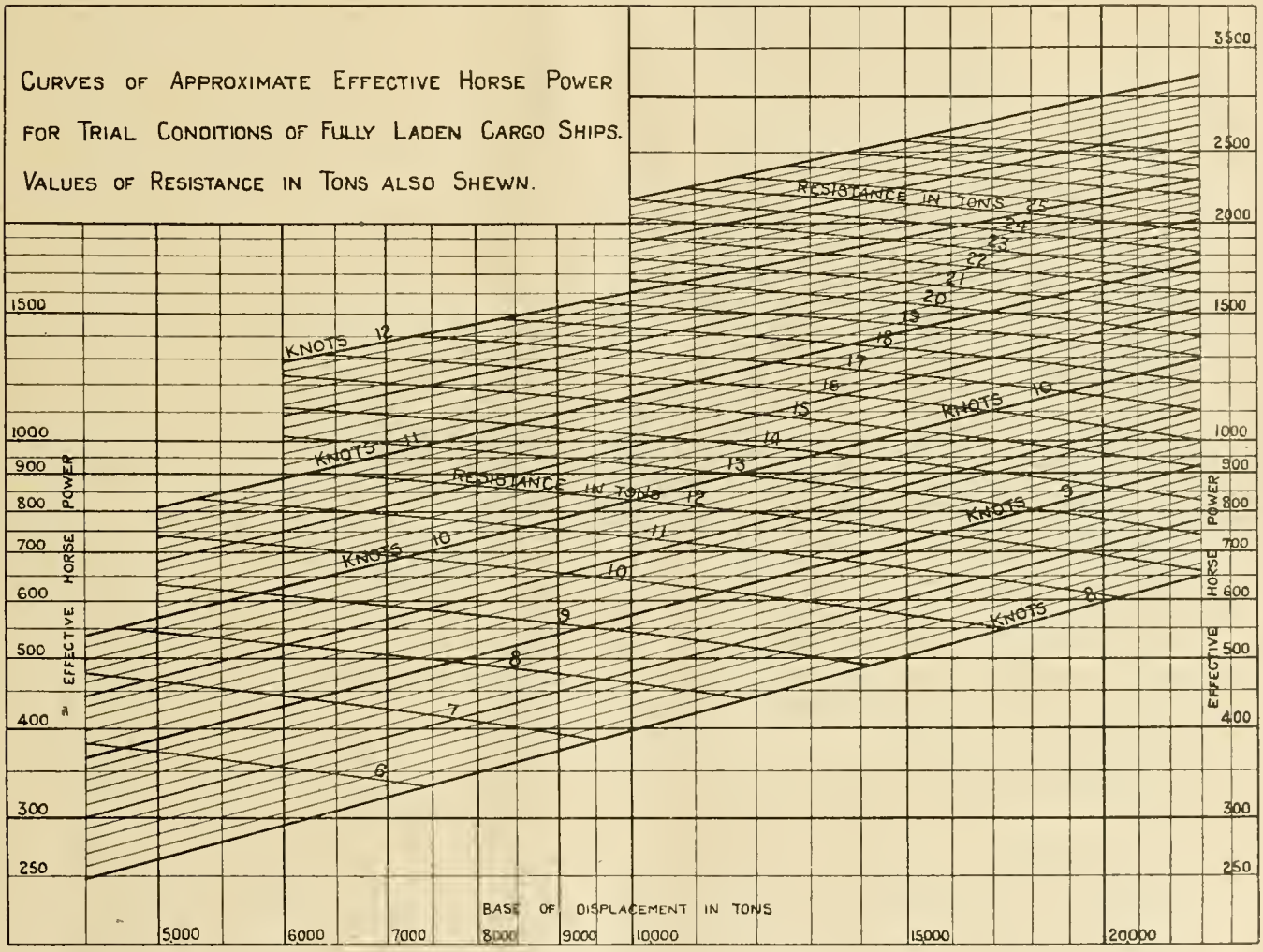


Fig. 3.—Curves of Approximate E.H.P.

In order quickly to arrive at comparative solutions certain liberties have been taken with Froude's formula for thrust; a constant value of "B" has been adopted and no correction has been made for the difference between effective and face pitch ratios.

The scheme of the analysis is as follows: A basic case has been chosen at a certain definite real slip, *i.e.*, 30 per cent., and the thrust-producing value of a screw 10 ft. diam. and unity pitch ratio with a propeller speed of 10 knots has been calculated. This calculation has been divided into two portions so that the effect of different dimensions and speed of propeller can be readily seen. On a base of real slip the values of the calculated thrusts in tons are set up at 30 per cent. slip, a straight line is drawn from zero thrust at zero slip through the value spotted at 30 per cent. slip. From considerations of the effective horse-power the resistance is

Account is then taken of the "thrust deduction," for the screws must produce a thrust equal to the augmented resistance of the ship. In the case of the *Suecia* this has been taken at 20 per cent., as suggested by Luke's results (T.I.N.A., 1910)—and in the single-screw ships of 25 per cent., as directed by McEntee's results obtained by experiments with models of single-screw vessels. (See Fig. 2.)

Having arrived, accordingly, at the thrust to be produced so as to maintain self-propulsion at the speed obtained, the real slip is read off from the calculated thrust curve at which this augmented resistance has been met by an equivalent thrust.

In order to arrive at the various factors comprising the propulsive efficiency value, it is necessary to know the speed of the wake following after the ship. The speed corrected for wake equals the speed of the propeller into the real slip, *i.e.*,

$Vp\ (1 - Sr)$. The relationships between apparent slip, real slip and wake are shown in the table of analysis. The speed of the propeller $Vp = \frac{\text{Pitch} \times \text{Revs.}}{101 \cdot 3}$; knowing the real slip V_1 or the speed corrected is obtained, and the thrust horse-power (T.H.P.) equals $\frac{\text{T in tons} \times V_1}{\cdot 1455}$.

Froude's "w" $= \frac{V - V_1}{V_1}$ and the hull efficiency $= (1 + w)(1 - t)$.

The Values Obtained.

Some of the results obtained are rather astonishing, and suggest that either something is wrong with the method of analysis or that abnormal conditions exist.

The method may be justified by the following example. Take the case of the *Mackay* with propellers 10·5 ft. diam. and 12·5 ft. pitch, revolving at 334·6 r.p.m. Then :—

$$D^2 V^2 p \frac{p + 21}{p} = 10 \cdot 5^2 \times 41 \cdot 3^2 \times \frac{22 \cdot 19}{1 \cdot 19}$$
$$= 110 \times 1710 \times 18 \cdot 65 = 3{,}510{,}000.$$

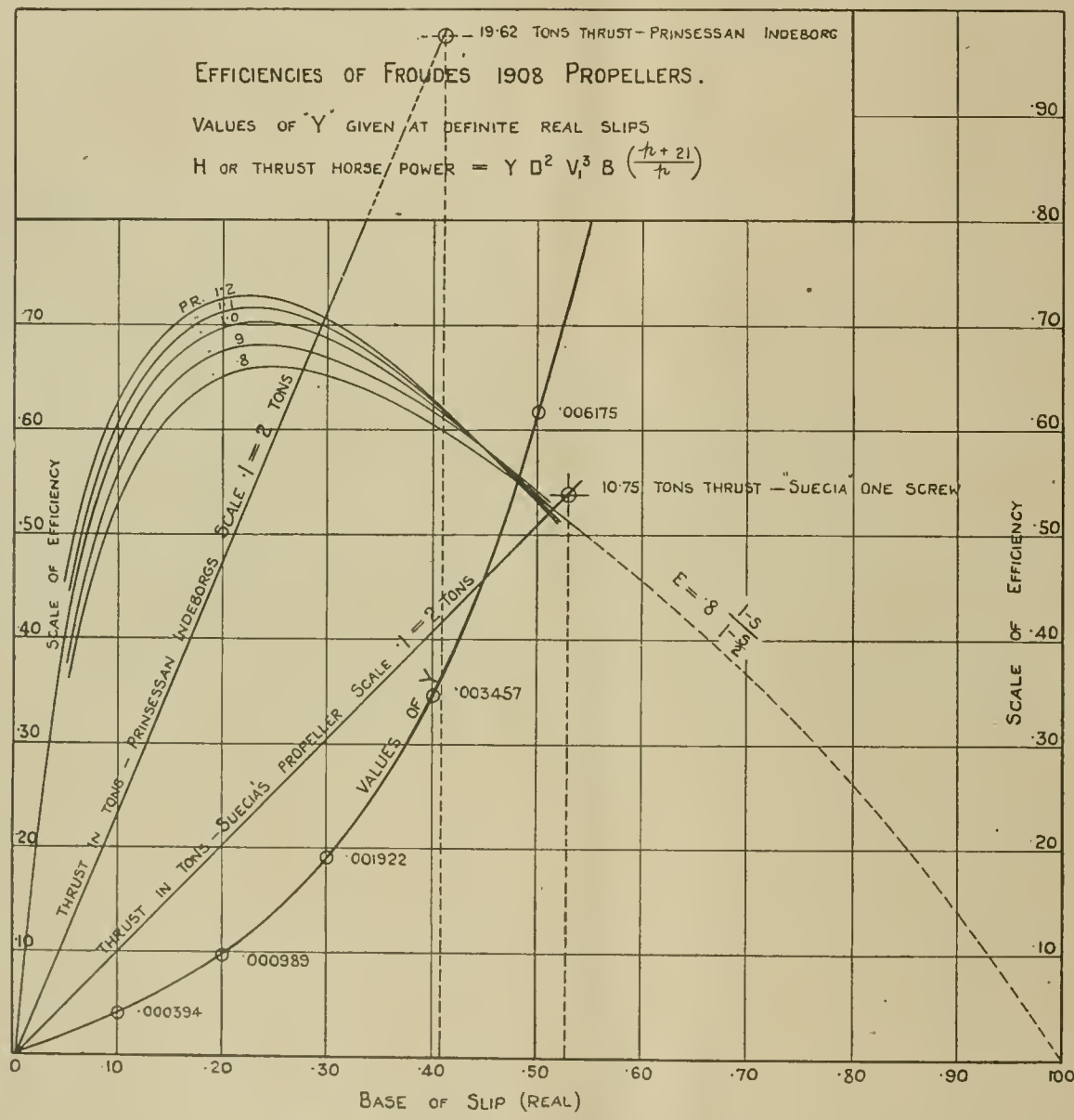

19·62 TONS THRUST – PRINSESSAN INDEBORG
EFFICIENCIES OF FROUDES 1908 PROPELLERS.
VALUES OF "Y" GIVEN AT DEFINITE REAL SLIPS
H OR THRUST HORSE POWER = Y D² V₁³ B ((p + 21)/p)
PR. 1·2
1·1
1·0
·9
·8
SCALE OF EFFICIENCY
THRUST IN TONS – PRINSESSAN INDEBORGS SCALE 1 = 2 TONS
THRUST IN TONS – SUECIA'S PROPELLER SCALE 1 = 2 TONS
VALUES OF Y
·006175
·003457
·001922
·000989
·000394
10·75 TONS THRUST – "SUECIA" ONE SCREW
E = ·8 (1 − S)
SCALE OF EFFICIENCY
BASE OF SLIP (REAL)
0 ·10 ·20 ·30 ·40 ·50 ·60 ·70 ·80 ·90 100

Fig. 4. Efficiencies of Froude's 1908 Propellers.

The propeller efficiency at the realised real slip can be taken from the curves on Fig. 4, on which are shown the "Y" curve and also the thrusts of the *Suecia's* and the *Prinsessan Ingeborg's* propellers. The T.H.P. divided by the propeller efficiency equals the shaft horse-power (S.H.P.), and the latter divided by the indicated horse-power gives the mechanical efficiency of the propelling machinery.

The total propulsive efficiency $= \frac{\text{E.H.P.}}{\text{I.H.P.}}$ = hull efficiency × propeller efficiency × engine efficiency × hull appendage factor. (The latter is the reciprocal of the increase in resistance due to appendages).

Values of all these factors are arrived at in the analysis.

This value, divided by the basic 220,000, = 16; and the thrust at 30 per cent. real slip = 16 × 3·467 = 55·5 tons. Mr. Frodsham Holt calculated the thrust to be 58·4 tons or 5 per cent. greater (see page 311, T.I.N.A., Vol. 62).

The *Mackay's* analysis gave values of "w," "t" and propeller efficiencies which were quite in harmony with former ideas as to what these should be. This points to the conclusion that abnormal conditions exist when slow speed ships are being driven by small propellers revolving at high rates of revolutions. It is possible, also, that owing to the greater relative thickness of actual screws as compared with model screws of corresponding proportions that these developed greater thrusts at definite real slips than the model results

ANALYSIS OF TRIALS OF VARIOUS FULL VESSELS.

(*a*) Twin-Screw Motor Ship *Suecia.*
(*b*) Single-Screw Motor Ship *Eavestone.*
(*c*) Single-Screw Steamer *Prinsessan Ingeborg.*

From Froude's 1908 Propeller Curves.

Where Y = Thrust factor.
D = Diameter of screw.
V_1 = Speed corrected per wake.
B = Blade factor (assumed ·115).
p = Pitch ratio (correction neglected).

Then T.H.P. $= YD^2 V_1^3 B \left(\frac{p+21}{p}\right)$.

Thrust in lbs. $= YD^2 V_1^2 B \left(\frac{p+21}{p}\right) 326$.

Thrust in tons $= YD^2 V_1^2 B \left(\frac{p+21}{p}\right) \cdot 1455$.

$= YD^2 V^2 p\ (1-S)^2 B \left(\frac{p+21}{p}\right) \cdot 1455$.

Assumed "basic" case—Where Diameter = 10 ft.
Pitch = 10 ft.
Vp = 10 knots.
Slip = 30 per cent.
Pitch ratio or p = 1.
Y = ·0001922.

Then thrust in tons for "basic" case $= Y(1-s)^2 B \cdot 1455, \left(D^2 V_p^2 \left(\frac{p+21}{p}\right)\right)$.

at 30 per cent. real slip $= (\cdot 001922 \times \cdot 49 \times \cdot 115 \times \cdot 1455)(100 \times 100 \times 22)$.
$= \cdot 00001576 \times 220{,}000$.
$= 3 \cdot 467$.

V = Speed of ship (in knots).
V_1 = Speed corrected for wake.
Vp = Speed of propeller $= \frac{\text{Pitch} \times \text{Rev.}}{101 \cdot 3}$

Apparent slip or $Sa = \frac{Vp - V}{Vp} : (1 - Sa) = \frac{V}{Vp}$

Real Slip or $Sr = \frac{Vp - V_1}{Vp} : (1 - Sr) = \frac{V_1}{Vp}$.

Speed of Wake $= V - V_1$.

Froude's "w" $= \frac{V - V_1}{V_1} : (1 + w) = \frac{V}{V_1}$.

and $\frac{(1 - Sa)}{(1 - Sr)} = (1 + w)$.

Effective horse-power or E.H.P. $= \frac{\text{Resistance in pounds} \times V}{326}$.
$= \frac{\text{Resistance in tons} \times V}{\cdot 1455}$.

Thrust horse-power or T.H.P. $= \frac{\text{Thrust in tons} \times V_1}{\cdot 1455}$.

		"Basic" Case.	*Suecia.*	*Eavestone.*	*Prinsessan Ingeborg.*
Diameter	D & D²	10′ 100′	10′ 100′	12·25 150	17·5 306
Pitch	P	10	8·16	10·62	17·5
Pitch ratio $\frac{P}{D}$	p	1	·816	·868	1·0
$\frac{p+21}{p}$	—	22	26·7	25·2	22
Revolutions	—	—	149	93·5	67·5
Speed of propeller	Vp	10	$\frac{8·6 \times 149}{101·3} = 12$	$\frac{10·62 \times 93·5}{101·3} = 9·81$	11·65
$D^2 V^2 p \left(\frac{p+21}{p}\right)$	—	$100 \times 100 \times 22 = 220{,}000$	$100 \times 144 \times 26·7 = 385{,}000$	$150 \times 96·5 \times 25·2 = 365{,}000$	$306 \times 136 \times 22 = 915{,}000$
Special case ÷ basic case	—	—	1·75	1·66	4·16
Thrust in tons at 30 per cent. slip	—	3·467	6·06	5·75	14·45
I.H.P.	I.H.P.	—	2140	1075	2050
E.H.P. (estimated)	E.H.P.	—	1150	115	1080
Speed of ship	V	—	11	9·38	11
Resistance in tons	R	—	15·21	6·41	14·3
Add for appendages	—	—	13 per cent.	3 per cent.	3 per cent.
Hull appendage factor	H.A.F.	—	·885	·97	·97
Resistance corrected	Rc	—	17·2	6·64	14·73
Thrust deduction	"t"	—	·20	·25	·25
Thrust $\left(\frac{Rc}{1-t}\right)$	T	—	21·50 10·75	8·85	19·62
Slip, real, at given T	Sr	—	·53	·455	·41
$Vp\ (1 - s)$ = speed corrected	V_1	—	5·64	5·35	6·87
T.H.P. $= \left(\frac{TV_1}{\cdot 1455}\right)$	T.H.P.	—	$\frac{10·75 \times 5·64}{\cdot 1455} = 417$	$\frac{8·85 \times 5·35}{\cdot 1455} = 325$	$\frac{19·62 \times 6·87}{\cdot 1455} = 925$
Froude's "w"	$\frac{V - V_1}{V_1}$	—	$\frac{11 - 5·64}{5·64} = ·950$	$\frac{9·38 - 5·35}{5·35} = ·753$	$\frac{11 - 6·87}{6·87} = ·601$
Hull efficiency $= (1 + w)(1 - t)$	H.E.		$1·950 \times ·8 = 1·56$	$1·753 \times ·75 = 1·315$	$1·601 \times ·75 = 1·20$
Propeller efficiency at real slip	P.E.	—	·51	·56	·62
S.H.P. $= \frac{\text{T.H.P.}}{\text{P.E.}}$	S.H.P.	—	$417 \div ·51 = 817$	$325 \div ·56 = 580$	$925 \div ·62 = 1490$
Engine efficiency $= \frac{\text{S.H.P.}}{\text{I.H.P.}}$	E.E.	—	$817 \div 1070 = ·765$	$580 \div 1075 = ·54$	$1490 \div 2050 = ·728$
Propulsive efficiency	$\frac{\text{E.HP.}}{\text{I.H.P.}}$	—	$1150 \div 2140 = ·538$	$115 \div 1075 = ·386$	$1080 \div 2060 = ·527$
= H.E. × P.E. × E.E. × H.A.F.	—	—	$1·56 \times ·51 \times ·765 \times ·885 = ·538$	$1·315 \times ·56 \times ·54 \times ·97 = ·386$	$1·20 \times ·62 \times ·728 \times ·97 = ·527$

indicate. Were this the case this would have the effect of (1) diminishing the real slip; (2) diminishing the wake; (3) diminishing the hull efficiency value; (4) increasing the screw efficiency. The latter point is not quite definite, for the thicker screws would have less efficiency at a definite real slip than would those of less blade thickness.

It will be observed that as the final result in the case of the *Suecia*, the engine efficiency works out at 76·5 per cent., which is close to that now generally adopted by Burmeister & Wain, so that the method seems to be justified by this final result.

Mr. Blache's Figures Compared with those obtained in this Analysis.

These figures differ very considerably from those given by Mr. Blache. Mr. Blache said that by fitting these motor ships with twin screws it was intended—with the revolutions chosen—to obtain the same propeller efficiency as was reckoned to be the standard for ordinary single-screw freighters when running at the number of revolutions usual with steam engines. His firm used Taylor's curves for propeller design—"Speed and Power of Ships"—and also Prof. McDermott's wake formula. His basic considerations for analysis are, therefore, fundamentally different from those here adopted, and much different results are arrived at. These for the *Suecia* are compared under :—

	Present analysis from Froude's Curves.	Mr. Blache's analysis from Taylor's 1910 Curves.
Wake (w)	0·950	0·165*
Thrust deduction (t)	0·20*	0·08
Hull efficiency $(1 + w)(1 - t)$	1·56	1·07

* Assumed.

	Present analysis from Froude's Curves.	Mr. Blache's analysis from Taylor's 1910 Curves.
Propeller efficiency	0·51	0·629
Engine efficiency . .	0·765	0·80*
Hull appendage factor	0·885	No allowance ?

* Assumed.

If Mr. Blache's values of "w" and "t" be accepted and used in conjunction with Froude's curves, the dimensions which would be given would be found to differ considerably from those of the screw actually fitted. The writer is inclined to the opinion that even from Taylor's curves the dimensions would differ from those Mr. Blache arrived at. This will be discussed more fully in the succeeding article.

The comparative figures above given show (1) from the "Froude's" analysis that the "wake" is probably much greater than that actually prevailing. The full-sized propeller gives evidently a thrust much greater than that suggested by Froude's formula. A diminution in the real slip and therefore in the wake would modify both the hull efficiency value and also the propeller efficiency. They also show (2) that the thrust deduction value in Mr. Blache's analysis seems much lower than that likely in a vessel of this fullness, especially when no allowance has been made (as far as the writer can gather) for the appendage resistance.

It is possible that an all-round adjustment would give figures more in harmony with general ideas as to the value of the various factors in the gross propulsive efficiency. These values would be of little use for propeller design unless new curves were constructed which took into account the results of actual experience as well as those obtained in tank experiments.

Oil Tank Steamer "Sjømand"—(*concluded from page* 15).

astern turbine is also arranged to exhaust direct through a nozzle to the condenser in the case of a breakdown in the L.P. turbine; direct steam can be admitted to the L.P. astern turbine in the case of a breakdown in the H.P. or I.P. turbines.

Steam is generated in two cylindrical boilers, each 14 ft. 9 in. diam. by 10 ft. 6 in. long, with a working pressure of 220 lb. per square inch. The boilers are fitted with superheaters. The total heating surface, exclusive of superheaters, is 4,000 sq. ft. Each boiler has three furnaces arranged to burn either oil or coal under natural draught conditions, the Thornycroft system of oil burning being installed.

Auxiliaries.

The following auxiliaries are fitted in the engine room :—

Centrifugal circulating pump with 11-in. connections	Drysdale.
Dual air pump, 9½ in. by 17 in. by 15 in.	Weir.
Pair of feed pumps with float control tank, 7 in. by 5 in. by 15 in. ..	Clarke, Chapman.
Two forced lubrication pumps, 5½ in. by 6 in. by 15 in.	Weir.
Two ballast and general service pumps, 5 in. by 5 in. by 6 in. ...	Thom. Lamont.
Electric light engine, 8½ kw.	Robey.
Evaporator, 15 tons in 24 hours ...	Caird & Rayner
Distiller, 1,000 galls. in 24 hours	Kirkaldy.
Feed heater	Holden & Brooke.
Two oil fuel pressure pumps, 4½ in. by 3 in. by 6 in.	Weir.
Fresh water pump, 3 in. by 2 in. by 3 in.	Hayward Tyler.

The following auxiliaries are provided for pumping cargo, oil or ballast, &c. :—

Two cargo oil pumps, 12 in. by 12 in. by 15 in. .	Thom. Lamont.
Two general service pumps in midship and ford. pump rooms .. .	6 in. by 6 in. by 6 in. Watson.
One bunker oil transfer pump	6 in. by 6 in. by 6 in. Watson.

Accommodation.

A feature of the vessel is the exceptionally comfortable quarters provided for the crew in the poop. In accordance with the Norwegian Board of Trade regulations there is a cabin for every two men, and these cabins are of a type and comfort which the "case-hardened old salt" used to regard as the prerogative of passengers. Each cabin is fitted with two galvanised-iron berths provided with a comfortable mattress and movable tables and seats, and separate bath rooms fitted with a good-size iron bath supplied with hot and cold water are provided for both firemen and sailors. The hospital is also situated in the poop.

The accommodation provided amidships for the officers reflects the highest credit on the builders and is really luxurious, the whole of this work having been carried out in a most artistic manner, only the very best materials and workmanship having been employed.

The galley is well lighted and ventilated, and fitted with a cooking range with two ovens and two fires, heated either by coal or oil fuel.

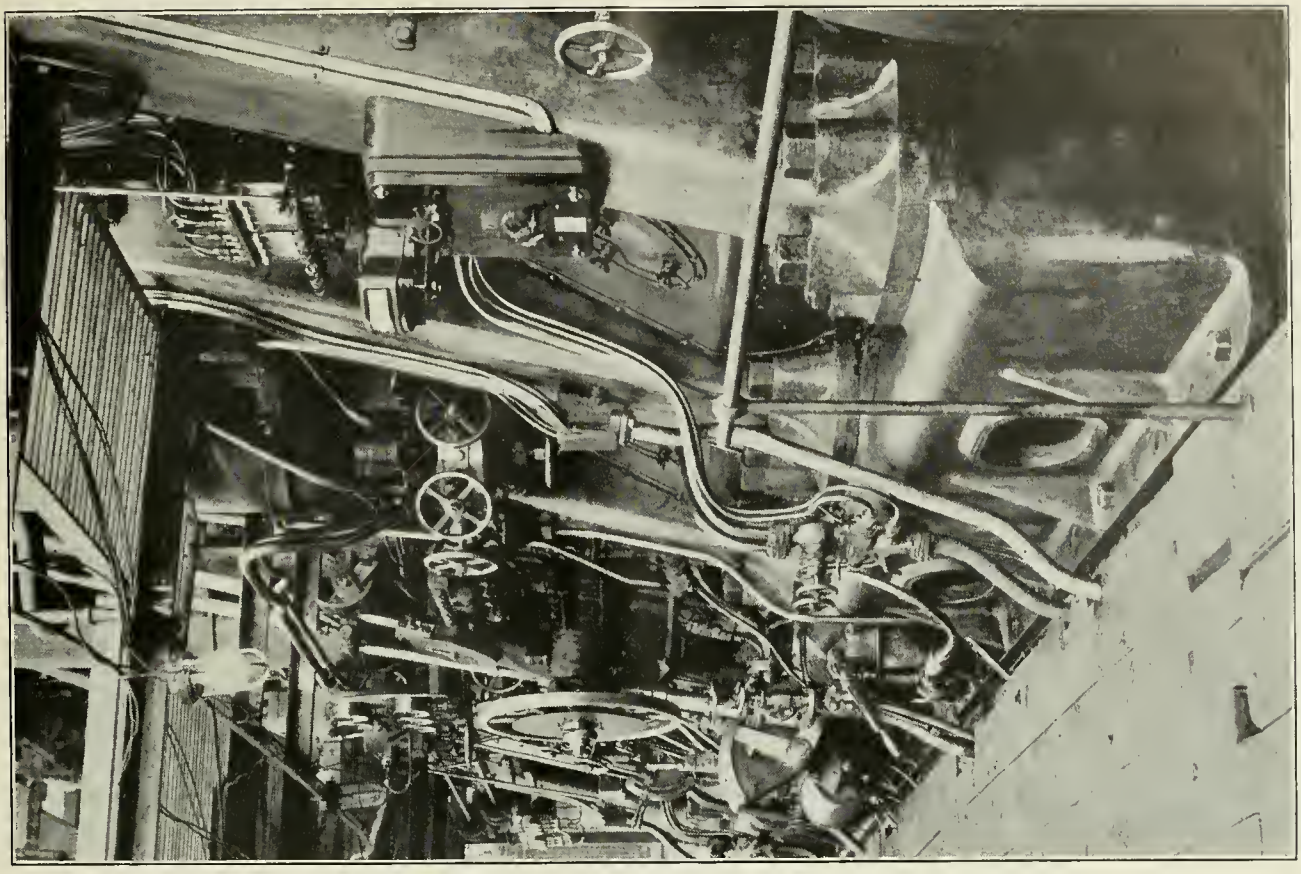
Trial Results.

In order that the trials might be carried out under conditions approximating to those which the vessel would meet with on service, the majority of the ten oil tanks were filled with water to the weight of about 4,000 tons.

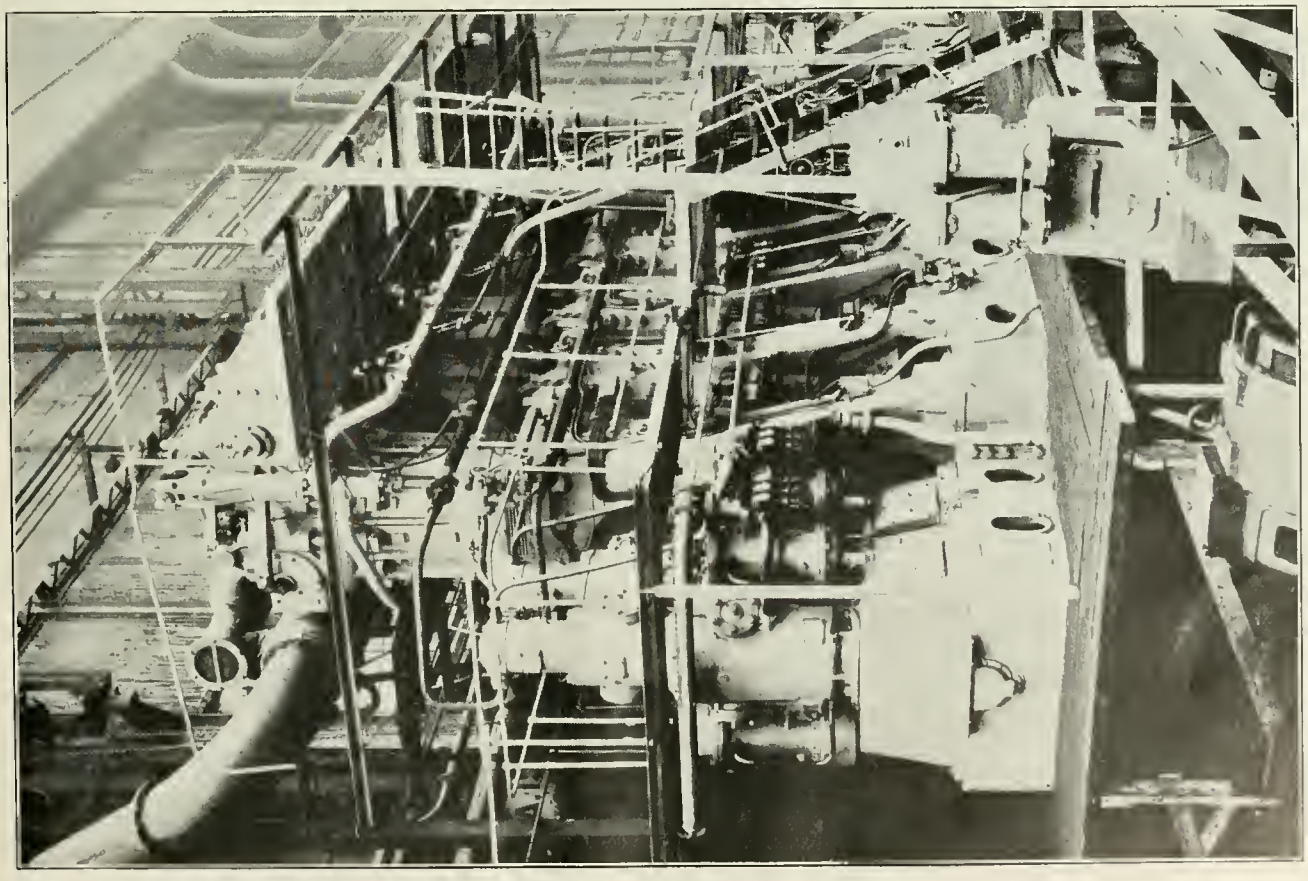
The vessel made four runs on the Admiralty measured mile at Stokes Bay, two with the tide and two against, when a mean speed of 10·9 knots was attained.

Following the speed trials, a four hours' consumption trial was carried out, during which the number of revolutions, and the steam and power, were very well maintained, the revolutions numbering 85.

The vessel has a bunker capacity of 750 tons of oil. From the point of view of handiness, the results were satisfactory. She travelled with extreme smoothness, and answered to her helm with remarkable promptitude.



Starting Platform of the Beardmore-Tosi Engine. (*See page* 36.)



Beardmore-Tosi Engine Complete in Erecting Shop.

Main Laboratory, looking West, of the North Eastern Marine Engineering Company Ltd.

Main Laboratory, looking East, of the North Eastern Marine Engineering Company Ltd.

LABORATORY WORK IN A MARINE ENGINEERING ESTABLISHMENT.

The Laboratory of the North Eastern Marine Engineering Company Limited— Influence on Foundry Work and Metal-Melting—Control of Castings.

The application of science to marine engineering is no new thing, since engineering itself is an applied science and recruits its ranks from scientifically trained men. It is a matter for wonder therefore that so little chemical and metallurgical science has heretofore been called for by engineers, and even in these days a fully equipped laboratory is regarded by those who should be intimately acquainted with engineering as something of a novelty. Yet the progress of engineering depends upon the production of more reliable materials and of new materials to meet conditions which have already exhausted the limits of usefulness of present materials.

The Balance Room.

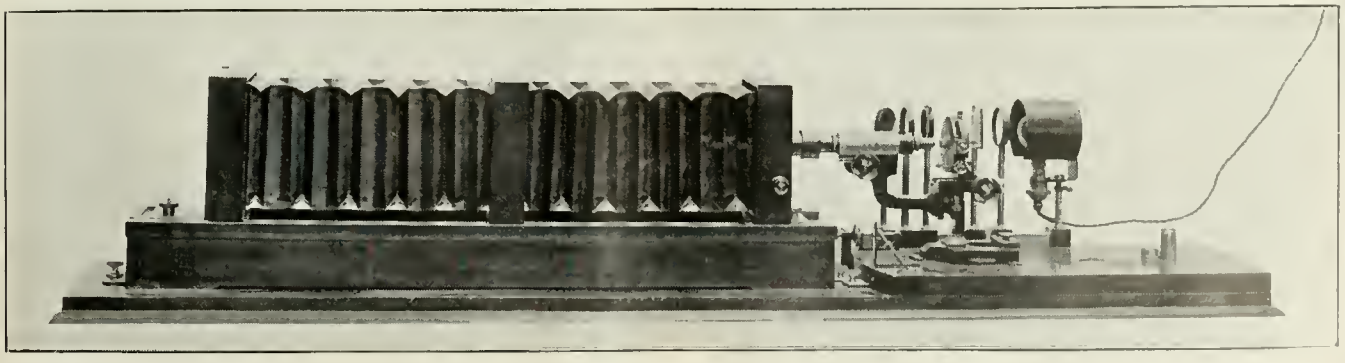
Broadly speaking, the energies of an engineering works revolve around the production of castings. The design of an engine is conceived and born in the shape of scientific and intricate drawings, then the pattern shop produces wooden patterns, the foundry makes a mould and fills it with metal, the machine shops trim up the casting, and finally the erecting shops put it into place—all this scientific and accurate thought and labour revolving around one article, namely, a casting. Astonishing though it may be, it is nevertheless true that the casting itself is frequently produced under unscientific conditions. Foundry work and metal-melting of a purely empirical and rule-of-thumb type obtains in many engineering works, while even some possessing laboratories use them in such a way as to gain little or no benefit from them.

Cast iron is a notoriously unreliable metal, and any improvements that can be made in the quality of iron castings will materially assist in the further development of marine engineering science, particularly as reliable cast irons must be found to meet the conditions peculiar to the internal-combustion engine. Practically all other commercial metals and alloys have undergone emancipation from prejudice and rule-of-thumb doctrines: steel, brass, bronze, gunmetal and aluminium.

In order to produce standard cast iron it is necessary to charge the cupola with standard mixtures. Every consignment of pig iron differs from the last. Indeed, most consignments differ throughout their own mass, hence it is obvious that a standard mixture must be compiled according to the variations in the pig irons that are available at the moment and by someone with academic as well as practical knowledge. The chemist must know what the foundryman knows and more besides. Having got a standard mixture it is charged into a cupola which of all melting furnaces is the most useful and economical and also the least understood and the least under control.

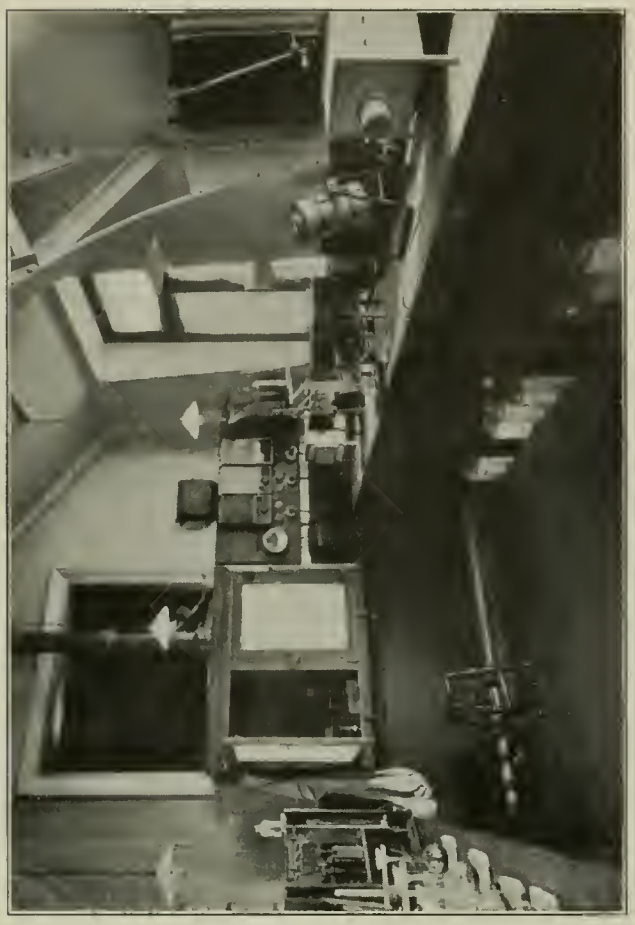
The elementary laws of combustion teach us that so much fuel requires so much air, but in a cupola the volume of air is not under control or even measurable by modern instruments. The average cupola and blowing apparatus are worked on rule-of-thumb methods which differ radically from works to works; so much so do these methods vary that it is a tribute to the elasticity of the cupola as a furnace that it gives any metal at all. Under adequate control it is possible to produce standard cast iron, not only from one foundry but from two or more foundries set widely apart and using different pig irons—this is being regularly accomplished at the two works of the North Eastern Marine Engineering Company Limited, one at Wallsend and the other at Sunderland.

Every consignment of pig iron is analysed and the mixtures balanced and adjusted accordingly; the cupola charges are weighed out and the cupolas regulated. When the molten

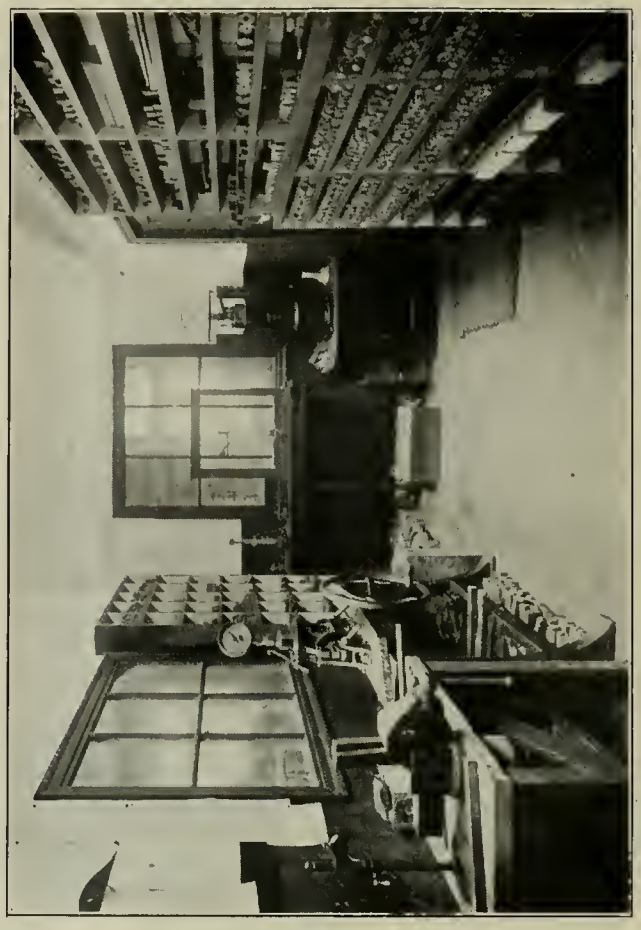


"Swift" Photo-micrographic Outfit.

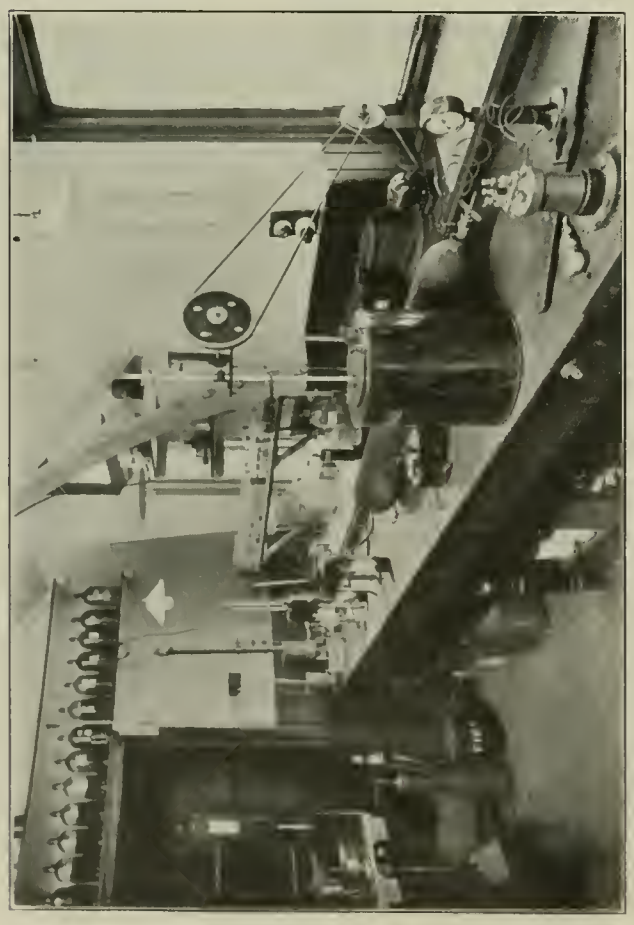
THE LABORATORY OF THE NORTH EASTERN MARINE ENGINEERING COMPANY LTD.



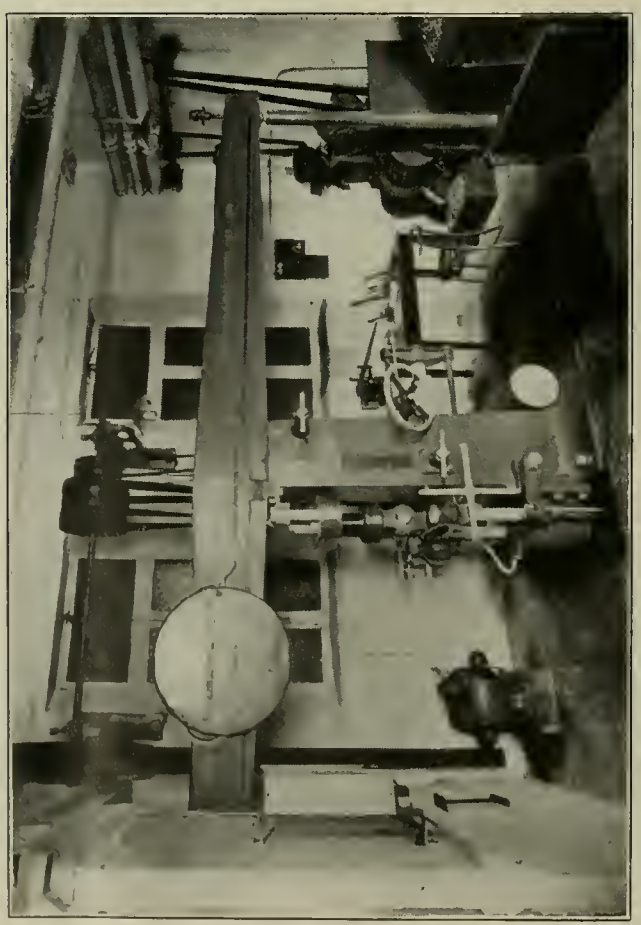
Combustion Room, showing Electric Furnaces, &c.



Testing Room, showing Transverse Machine and also Brinell Hardness Machine.



Oil and Fuel Laboratory.



Testing Room, showing Buckton 50-ton Testing Machine.

metal appears at the tap hole its temperature is taken and test bars are cast from the metal in the ladle just before the casting is poured—these test bars being quite apart from any others that may be required. Next morning the test bars are tested for transverse strength, the tensile strength and hardness being also observed in important cases, and most of them are analysed. This procedure is finished generally before the casting, which the bars represent, is removed from its mould, certainly before it reaches the machine shops.

The result of such control is that any departure from the normal is known almost immediately, and does not go on indefinitely before its effects are discovered. Another result is that the same class of casting can continually be made of precisely the same class of material. Finally, in case of unusual success or failure of that particular casting, either in internal-combustion engines, and they are also in a position to produce on a works scale anything that may be discovered at any moment. A special cupola for this work has been recently erected, and most exhaustive tests and experiments are in progress with a view to calibrating this furnace.

We reproduce on pages 28–30 some photographs of the laboratory at the Wallsend Works of the North Eastern Marine Engineering Company Limited. It is impossible to show the whole of the department, the offices and the dark room being equally well equipped, and there is a separate building wherein are experimental furnaces for the melting of cast iron and also a drilling machine for sampling purposes.

The control books in use in this laboratory are of particular interest, and we reproduce specimen sheets on this and subsequent pages.

CUPOLA CONTROL. 802

N E M E Co. Ltd., Wallsend. Laboratory. Date 31st July 1914. Signature J. R.

SUBJECT		First 10 Charges	Next 7 Charges	Next ... Charges
MIXTURE	Name or Number	Cyl	Job	
"	Weighed (charges or bulk)	Charges	Charges	
"	Metal per charge lbs.	2000	2000	
"	Coke " lbs.	210	210	
"	Limestone " lbs.	40	40	
"	Fluorespar " lbs.	—	—	
"	Other details	—	—	
CUPOLA	Name or Number	Middle		
"	Time of Lighting	9.10		
BED	Time of Making	10.0 to 10.25		
"	Distance from Chrg Door	10 ft 6 in		
"	Height above Tuyeres	2 ft 0 in		
"	Weight of Coke lbs.	650		
"	Other details	"		
KINDLING TUYERES (or cupola doors)	Time of Using	1.15 to 1.20		
TOTALS	Metal charged lbs.	34,000		
"	Coke " lbs.	3,410		
"	Coke used lbs.	4,060		
"	1 of Coke (charged) melted	9.97		
"	1 " (used) "	8.37		
"	1 of Limestone fluxed	50	58	

CUPOLA CONTROL. 802

N E M E Co Ltd Wallsend Laboratory. Date 31st July 1914. Signature J. R.

MATERIAL	CHARGES No	Time	Weight lbs	No	Time	Weight lbs.	OTHER DETAILS. Gas Samples No	TIME
Metal	1	10.10	2,000	12	3.0	2,000		
Coke	1	10.33	210	12	3.4	210	1	1.30
Metal	2	10.36	2,000	13	3.19	2,000	2	2.0
Coke	2	10.38	210	13	3.23	210	3	2.30
Metal	3	10.43	2,000	14	3.36	2,000	4	3.0
Coke	3	10.47	210	14	3.40	210	5	3.30
Metal	4	10.54	2,000	15	3.53	2,000	6	4.0
Coke	4	10.57	210	15	4.0	210	7	4.30
Metal	5	11.5	2,000	16	4.17	2,000	8	5.0
Coke	5	11.9	210	16	4.21	210		
Metal	6	11.13	2,000	17	4.34	2,000	Note No limestone in last charge only 50 lbs coke	
Coke	6	11.40	210	17	4.36	50		
Metal	7	11.46	2,000	18				
Coke	7	11.49	210	18				
Metal	8	12.1	2,000	19				
Coke	8	12.3	210	19				
Metal	9	12.14	2,000	20				
Coke	9	12.17	210	20				
Metal	10	12.27	2,000	21				
Coke	10	12.30	210	21				
Metal	11	12.42	2,000	22				
Coke	11	12.44	210	22				

Specimen pages from Cupola Control Book.

the works or after years of service, the whole of the conditions are known and can be repeated or avoided as the case may be.

Another benefit arising directly from such work is that the foundry has little use for the higher priced pig irons. It makes its own mixtures, and what one pig iron will not give is got by incorporating other pig irons until the final result is the one required.

It is when the question arises of producing special metals for such things as super-heat cylinder liners and Diesel castings that one reaps a further benefit from scientific foundry control, and the North Eastern Marine Engineering Company have been able to produce a cylinder liner metal of very high standard and different from any other.

A considerable amount of work has been done by this company towards the production of the best possible metal for

The books used for records of mixtures and alloys, cupola control and outside control, are each made to be used from the centre, the leaves of the cupola and outside control books being perforated, so that they can be detached and filed after the necessary data has been filled in. The cupola weigh sheet is a single sheet blank on the reverse side.

These record sheets serve to show how intricate and how little known are the various phases of cupola practice, at the same time indicating how the analyses of the fuels, fluxes, raw metals, gases, slags and testing of the metals produced all enter into the work of making cast iron to meet and anticipate the conditions of modern engineering and of engineering of the future.

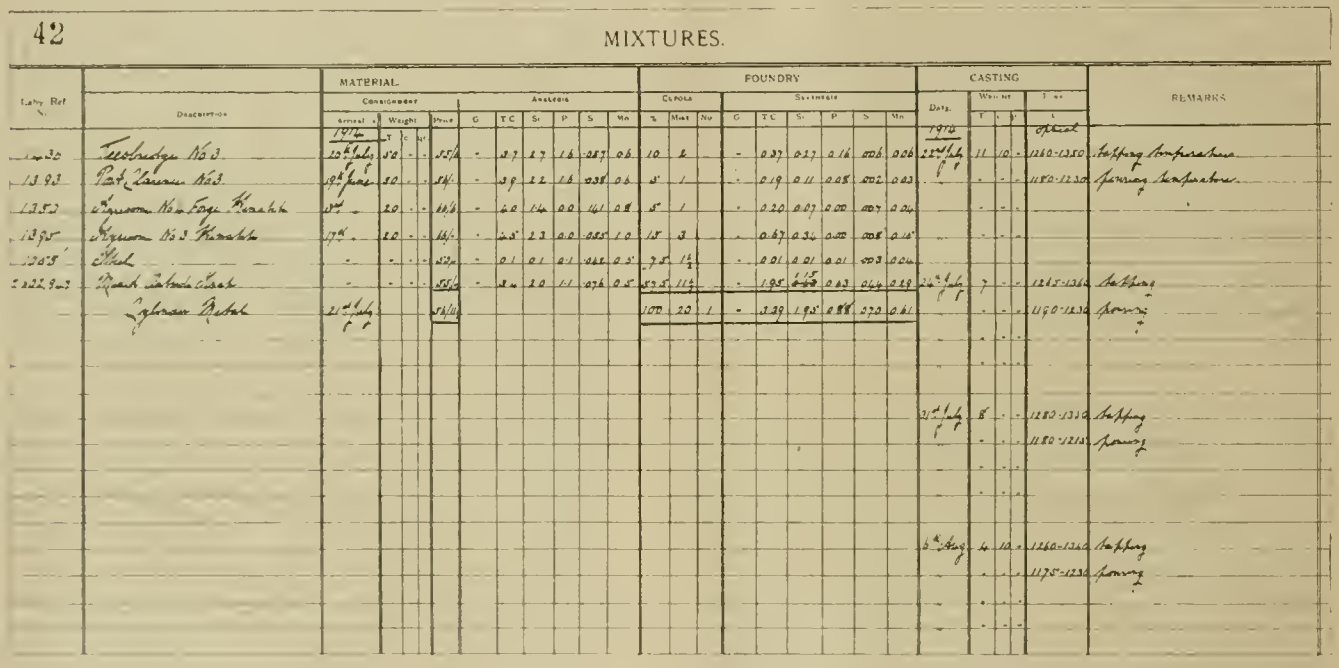
A high-grade microscope and optical bench provide means of studying and photographing the structures of the iron and the nature and disposition of its constituents. This work is

particularly important when the properties of the casting itself are to be considered as not necessarily being the same as those of the test bar on the casting—and in cast iron this is practically always the case.

The work of a laboratory in the brass foundry is already well known and recognised, and here again have the compositions and manufacture of the various alloys to be kept constant and under control. Certain castings on a marine engine are apt to give trouble, and in those cases extra control and considerable research work is done. Naturally and obviously the continual turning out of analyses is merely futile work unless something is done with the data by trained metallurgists. In the North Eastern Marine Engineering Company the laboratory deals with its own work and applies its own methods in the works. It works in co-operation with the foremen, for only by such co-operation is any substantial progress to be made. Education of foremen and apprentices is by no means the least important sphere of action in which the laboratory can take a leading part.

The many other supervisions and inquiries undertaken in this department are too numerous to be mentioned in detail. There are the questions of lubricants and of liquid fuels, both very important in these days of oil-burning and of internal combustion. The effects of high temperatures, of oil or water corrosion, and the thousand and one conditions arising out of the manufacture and use of marine engines and boilers, all come into the net of the works' laboratory. Things which in the past were regarded as insoluble mysteries are now recorded and investigated whenever they appear to possess commercial importance.

The records of a works' laboratory are essentially its most valuable asset. The department under consideration is entirely self-supporting, it takes its own samples, does its own work and applies it in the works without outside aid. It directs the purchase of raw materials and the manner of their use. It follows the manufactured article from its birth onwards, and keeps a watch on what is being done by other firms both here and abroad. Its library is extensive, and it follows all current literature and keeps pace with modern thought and recent discoveries. Finally, we may note that the department was established nearly eleven years ago, and has been continuously under the direction of Mr. H. J. Young, F.I.C.



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MIXTURES.

Lab. Ref. No.	Description	MATERIAL. Consignor	Arrival	Weight	Date	Analysis G	TC	Si	P	S	Mn	FOUNDRY. Cupola %	Mat	No	Sandridge G	TC	Si	P	S	Mn	CASTING. Date.	Weight T	c	q	Test	REMARKS
			1916	T c q																	1916				
1392	Teesbridge No 3		20 Feb	50 - -	15/2	-	2.7	1.7	1.6	.087	.06	10	2	-	-	0.37	0.27	0.16	.006	0.06	22 Feb	11	10	-	1180-1350	Satisfactory temperature
1393	Part Tarran No 3		9 Feb	10	5/4	-	3.9	2.2	1.6	.038	.06	5	1	-	-	0.19	0.11	0.08	.002	0.03		-	-	-	1150-1250	Running temperature
1350	Tarran No 2 Forge Scrap		3	20	16/3	-	4.0	1.4	0.0	1.41	0.8	5	1	-	-	0.20	0.07	0.00	.007	0.04		-	-	-		
1395	Tarran No 3 Scrap		7	20	14/-	-	2.5	2.3	0.0	.055	1.0	15	3	-	-	0.67	0.34	0.00	.008	0.15		-	-	-		
1365	Steel		-	-	15/2	-	0.1	0.1	0.1	.041	0.5	75	14	-	-	0.01	0.01	0.01	.003	0.04		-	-	-		
2229-3	Rack Cotsbrook Cast		-	-	15/2	-	3.4	2.0	1.1	.076	0.5	53.5	11.5	-	-	1.95	0.65	0.03	.014	0.19	26 Feb	7	-	-	1265-1360	Satisfactory
	Tarran Return		21 Feb		15/10							100	20	1	-	3.39	1.95	0.88	.070	0.61		-	-	-	1150-1250	Running
																					21 Aug	8	-	-	1180-1310	Satisfactory
																						-	-	-	1180-1210	Running
																					5 Aug	4	10	-	1260-1320	Satisfactory
																						-	-	-	1170-1230	Running

Specimen pages from Records of Mixtures and Alloys from

EXTENSIONS OF JOHN G. KINCAID & CO.'S WORKS.

Of recent years quite a number of the engineering and shipbuilding establishments in the Clyde have been extending their premises, and among these are the works of John G. Kincaid & Co. Limited, Greenock. The firm, which is an old-established one, celebrated its jubilee in 1918. In 1912 the firm decided to build an erecting shop of large dimensions at the west end of their existing buildings. This shop was 200 ft. in length by 62 ft. in span, and its average height was 42 ft. 6 in. to crane rail, which height gave ample headroom for the building of engines up to largest size. This building was completed in 1913, and the enterprise of the firm found them in an excellent position to tackle the necessary pressure of early war work in the autumn of 1914.

Soon after the commencement of the war, J. G. Kincaid & Co. found it necessary again to make a step in the direction of extensions, and within six months they put in hand the construction of new shops of a total floor area of 30,000 sq. ft. These shops comprised: A new funnel shop 200 ft. in length by 50 ft. span with a height to crane rail of 30 ft. The carrying capacity of the crane beams in this shop is 30 tons and the building is equipped with cranes of this weight. Two machine shop bays were added parallel to the erecting shop, one 172 ft. in length by 42 ft. span and one 130 ft. by 42 ft. span. These shops have adequate travelling crane facilities, and furthermore, are equipped with galleries which have a floor area of 6,500 sq. ft. An addition of 120 ft. was made to the erecting shop, making its total length 320 ft. Not content with these improvements, Kincaid's, early in 1916, again considered the question of extensions. It embraced the radical alteration of their railway siding accommodation in order still further to facilitate the handling of raw materials. One boiler shop 300 ft. in length by 72 ft. in span with a height of 36 ft. 6 in., carrying efficient electric crane, is completed, also another boiler shop 230 ft. in length with a height to crane rail of 49 ft. carrying a 75 ton high-speed travelling crane. Until recently the capacity of the plant was equal to ten sets of marine engines and boilers a year, but now that the extensions are completed it is equal to from 26 to 30 sets of engines and 120 to 130 boilers per annum.

ELECTRIC AUXILIARIES ON MERCHANT SHIPS.*

Mr. Edgar Dickinson gives some interesting figures to the New York Society of Naval Architects.

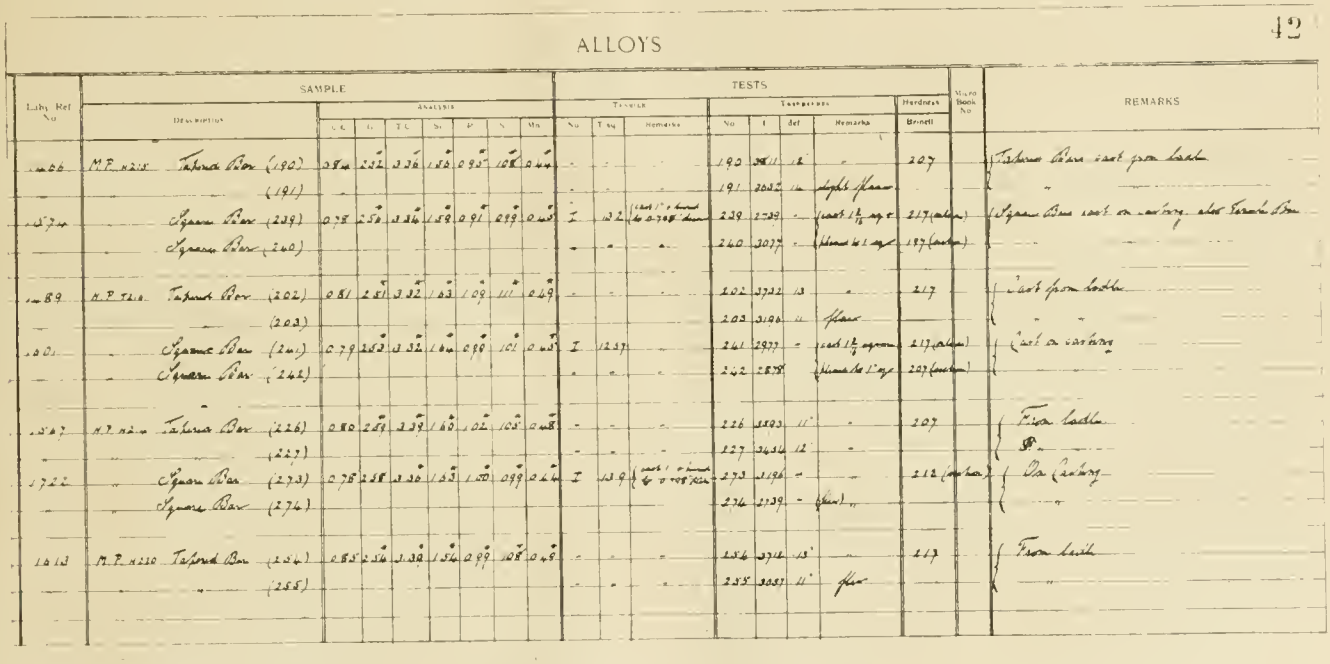
On highly efficient new ships, especially motor ships, practically all the auxiliaries are driven by electric motors. In the motor ship the steam boiler becomes an auxiliary, and it is apparent that much of the gain in economy secured by the oil engine would be sacrificed if steam auxiliary machinery were retained. In the steamship, the losses incidental to the steam auxiliaries are not so apparent; nevertheless, they are there, a constant drain on the boilers and a continual handicap to any operator or engineer endeavouring to attain efficiency in operation.

It is recognised that a somewhat greater gain in fuel economy is generally secured on a motor ship by the adoption of electricity for the reason that Diesel engines are employed to drive the generators. Oil engines might be used on steamships with a resultant reduction of fuel required for all purposes. However, there are certain good operating reasons why such an arrangement is not generally popular. It would be necessary to have an engineering staff competent to operate and maintain the oil engine. As the pumps, essential to the operation of the ship's main engine, would be driven electrically, any interruption of the auxiliary oil engine might seriously interfere with the operation of the ship. Fuel oil would have to be suitable for the Diesel engine, and in some cases this might necessitate carrying two kinds of fuel oil on board with the incidental disadvantages. Duplicate equipments for heating, storing and filtering fuel oil would have to be installed. On a steamship, therefore, the most generally accepted practice is to install turbine-driven generator sets for auxiliary power.

Not much information has been published relating to the details of costs of operation of ships. Studies indicate that on new ships electric auxiliaries will show a marked improvement in the economy of operation and will increase the net earning capacity. The future will show that many existing ships can be operated profitably by the substitution of electric for steam auxiliaries. The reasons for expecting such big savings are not at once apparent. Investigations indicate that the losses are partly due to innumerable small leaks and to radiations; in other words, it is the steam which is generated in the boilers but not put to useful work that, in a great measure, accounts for the high fuel consumption of many steam-driven ships.

Auxiliary machinery on ships can be readily subdivided into two broad types: (*a*) For deck use; (*b*) for below-deck use. Deck machinery, properly speaking—that is, all machinery which is exposed to the elements and which must be built with this in view—consists generally of cargo winches, anchor windlass, a certain number of capstans, mooring winches and sometimes special machinery on particular ships. It is true that the steering machinery is not generally exposed to the elements, but is, however, very often housed in an extremely damp compartment. Continuous operation is vital to the safety of the ship. It will be evident that only machinery designed and built for the service should be considered for the application. The service of deck machinery is of an intermittent nature except in some special ships, that is, certain tankers where the motors for driving the cargo pumps are mounted on deck. Electric deck machinery has been developed along two fundamentally distinct lines: one in which the motor is mechanically geared to the drums, and the other where some form of hydraulic speed-reducing gear is fitted between motor and drum. The latter class seems to have found considerable favour abroad.

There are many special applications of electricity to machinery for shipboard not normally included as part of the regular equipment of a cargo ship wherein the use of electricity is particularly well suited. By the proper application of principles already worked out, it will be found that towing engines, mooring winches and other special pieces of machinery can be built to operate electrically in a very simple manner and with as great, or greater, reliability than steam machinery already developed.



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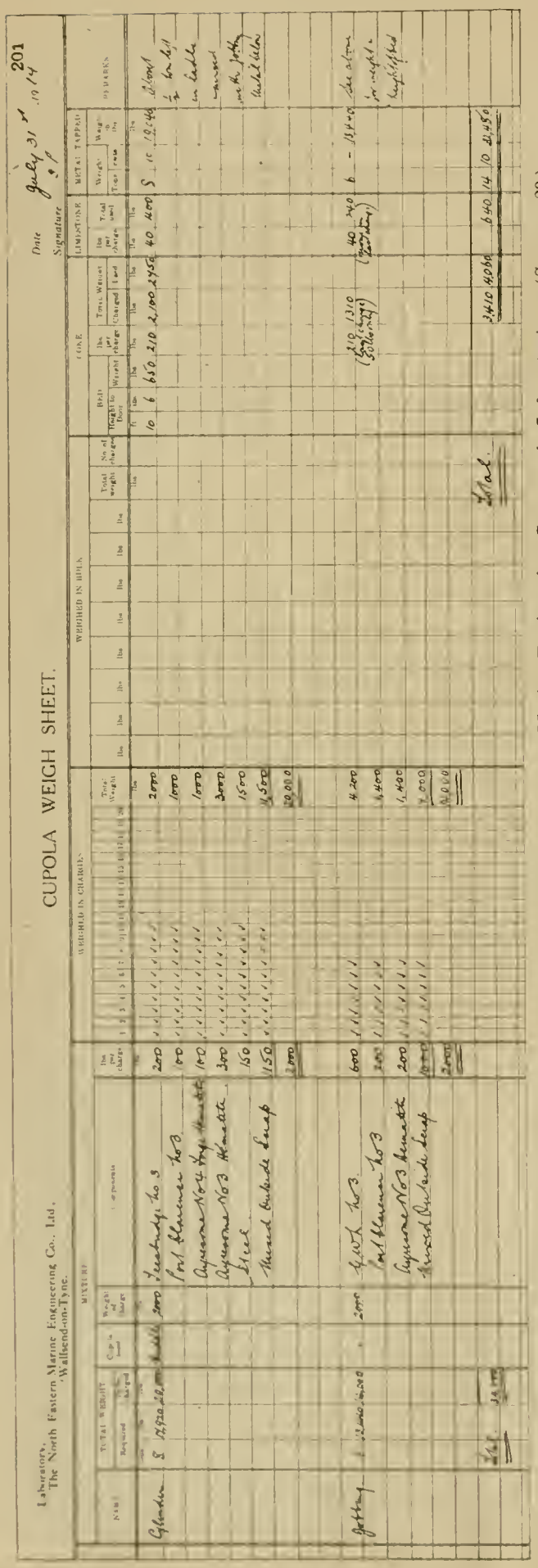
ALLOYS

Lab. Ref. No.	SAMPLE Description	Analysis	TESTS Tensile	Temperature	Hardness Brinell	Work Book No.	REMARKS
1466	M.P. H.P. Tobin Bronze (190)	Cu 84 Sn 5.2 Zn 3.6 Pb 1.8 Fe 0.95 Ni 1.8 Mn 0.44		190 2811 12	207		Tobin Bronze cast from bottle
	(191)			191 2802 " light flow			"
1574	Gyro Bronze (239)	Cu 87.5 Sn 5.2 Zn 3.46 Pb 1.58 Fe 0.91 Ni 0.99 Mn 0.43	1 32 [illegible]	239 2739 - cast 1½ up	217 (calc.)		Gyro Bronze cast in sand by also Tobin Bronze
	Gyro Bronze (240)			240 3017 - flow 1½ up	187 (calc.)		
1489	M.P. H.P. Tobin Bronze (202)	Cu 81 Sn 5.1 Zn 3.32 Pb 1.83 Fe 1.09 Ni 1.11 Mn 0.49		202 3732 13 "	217		Cast from bottle
	(203)			203 3196 11 flow			"
1501	Gyro Bronze (241)	Cu 87.9 Sn 5.2 Zn 3.32 Pb 1.62 Fe 0.96 Ni 1.01 Mn 0.43	1 123	241 2977 - cast 1½ up	217 (calc.)		Cast in sand
	Gyro Bronze (242)			242 2878 flow 1½ up	207 (calc.)		
1567	M.P. H.P. Tobin Bronze (226)	Cu 80 Sn 5.1 Zn 3.38 Pb 1.65 Fe 1.02 Ni 1.05 Mn 0.48		226 3893 11 "	207		From bottle
	(227)			227 3434 12 "			"
1722	Gyro Bronze (273)	Cu 87.8 Sn 5.18 Zn 3.30 Pb 1.53 Fe 1.00 Ni 0.99 Mn 0.42	1 139 [illegible]	273 3196 - "	212 (calc.)		Da Sand
	Gyro Bronze (274)			274 3139 - flow "			"
1613	M.P. H.P. Tobin Bronze (254)	Cu 85.5 Sn 5.26 Zn 3.38 Pb 1.56 Fe 0.98 Ni 1.08 Mn 0.49		254 3714 13 "	217		From bottle
	(255)			255 3057 11 flow			"

the Books of the North Eastern Marine Engineering Company's Laboratories.

* Abstract of a paper read at the twenty-ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 17 and 18, 1921, by Mr. Edgar D. Dickinson.



CUPOLA WEIGH SHEET.

Laboratory,
The North Eastern Marine Engineering Co., Ltd.,
Wallsend-on-Tyne.

Specimen page from Cupola Weigh Sheet in use at the North Eastern Marine Engineering Company's Laboratories. (See page 29.)

The following is a table of deck machinery which, with slight modification, would be applicable to ships of any tonnage between 8,000 and 10,000 tons d.w. It should be borne in mind that the size of the cargo winches is based upon the best practice for general cargo and therefore does not vary greatly with the size of the ship. The number of winches, however, has to be modified to suit the number of hatches and derrick booms of the different ships.

	No. Units.	Assumed Motor Horse-power.	Duty.
Anchor windlass	1	70	Very intermittent, severe. Often submerged. May be stalled in operation.
Cargo winches	12	35	Intermittent. Fast cycle, severe duty. Sometimes submerged. Wide range in loads and speeds.
Steering gear	1	35	Seldom fully loaded. Severe intermittent duty with mechanical gear. Moderate continuous duty with hydraulic gear.

TYPES DEVELOPED (ELECTRIC DECK MACHINERY).

	Drive.	Motor.	Speed Control.
Anchor windlass and capstan.	Spur gear	Reversing	Electric.
	Worm gear	Reversing	Electric.
	Hydraulic	Constant speed.	Hydraulic.
Cargo winch	Worm gear Spur gear	Reversing	Electric with electric brake (general use).
		Reversing	Electric with mechanical brake.
		Constant speed.	Mechanical brake and clutch (free drum winch).
		Constant speed.	Mechanical brake hoisting and lowering clutches.
		Constant speed.	Reverse gear and brake.
		Constant speed.	No speed control (winch head only).
	Hydraulic	Constant speed.	Hydraulic.
Steering gear	Spur gear	Reversing	Electric.
	Worm gear	Reversing	Remote.
	Hydraulic	Constant speed.	Hydraulic.

Below-Deck Machinery.

The greater part of the electrical machinery below deck is naturally located in the engine room. The following table gives a list of below-deck auxiliaries suitable for a cargo ship of about 8,000 to 10,000 d.w. tons and equipped with 2,500 to 3,000 shaft horse-power steam turbine. A motor ship requires somewhat fewer auxiliaries, and slightly less power is necessary for driving them. Tankers require a number of motor-driven pumps for discharging the cargo. These may be installed either in a special pump room or arranged with the motors on deck with vertical shafts to the pump below. It will be noted that in the list there are only five sizes of motors. That is with the intent of simplification and to reduce the number of spare parts to be carried. A study of particular cases may show that it is possible to satisfactorily arrange the engine-room equipment so as to have still fewer sizes.

BELOW-DECK AUXILIARIES.

	No. Units.	Assumed Motor Rating in Horse-Power.	Duty.
Propulsion—			
1. Circulating pump	1	40	Continuous at sea.
2. Boiler feed	2	25	One continuous at sea.
3. Forced draught fan	1	20	Continuous at sea.
4. Condensate	1	5	Continuous at sea.
5. Lubricating oil	2	5	One continuous at sea
6. Oil cooler water	1	5	Continuous at sea.
7. Fuel oil	2	5	One continuous at sea.
8. Fuel oil trans.	1	5	Intermittent (assume 4 hours per day).

	No. Units.	Assumed Motor Rating in Horse-Power.	Duty.
Service—			
9. Fire and bilge ..	1	10	Intermittent (assume 6 hours per day).
10. General service	1	10	Intermittent (assume 6 hours per day).
11. Sanitary	1	5	Intermittent (assume 12 hours per day).
12. Fresh water	1	5	Intermittent (assume 2 hours per day).
13. Refrigerating ...	2	5	One continuous at sea.
14. Evaporator ..	1	5	Intermittent (assume 3 hours per day).
15. Ballast	1	10	Intermittent (assume 4 hours per day).
16. Workshop	1	5	
17. Oil purifier . .	1	5	
18. Galley	1	5	

Generating Units.

A study of the installations on a number of cargo ships of various tonnages indicates that on a steamship 150 kw. would give ample power for the deck machinery when in port and for the entire engine-room equipment when at sea. On a motor ship about 75 kw. are necessary at sea. Therefore, on cargo ships of about 10,000 d.w. tons, two 150 kw. steam turbines or on the motor ships three 75 kw. generator sets would give ample power with one unit for a standby at all times. The auxiliary power in many cases will be much greater than 150 kw. on refrigerator ships and on ships fitted in part for passenger service. The larger the amount of auxiliary power the greater the reason for highly efficient auxiliary turbines. Some studies have shown requirements for auxiliary power as great as 1,500 kw.

(*To be continued.*)

802 OUTSIDE CONTROL.

N.E.M.E. Co. Ltd., Wallsend Laboratory. Date. 31st July 1914 Signature J.R.D.

BLAST. Time	BLAST. Pres lbs.	BLAST. Vol. c.f.p.min.	MELTING. Tap No.	Time Started.	Time Finished	Temp °C.	Approx Weight. tons.	REMARKS
1·30	31·8	120	(Blast on)	1·26	–	Observed.	–	
1·45	30·8	114	(First metal)	1·35	–	–	–	
2·0	33·6	116	1	2·15	2·19	1280 / 1280	3	
2·15	32·8	118		–	–	1300 / 1320	–	
2·30	31·0	120	2	3·1	3·3	1320	2½	
2·45	32·9	121		–	–	1340 / 1350	–	
3·0	32·3	114	3	3·40	3·43	1330	2½	
3·15	33·8	119		–	–	1340 / 1350	–	
3·30	33·1	118	4	3·50	3·51	1340	½	
3·45	34·1	120		–	–	1350	–	
4·0	33·4	120	5	4·26	4·29	1320 / 1330	2½	
4·15	33·1	118		–	–	1340 / 1350	–	
4·30	32·5	116	6	4·50	4·52	1360	1½	
4·45	33·1	114		–	–	1370 / 1375	–	
5·0	32·8	118	7	5·11	5·13	1350 / 1360	1½	
5·15	29·3	106		–	–	1340 / 1345	–	
			8	5·19	5·20	1340 / 1350 / 1360	½	
				–	–		–	
			9					
				–	–		–	
			10					
				–	–		–	
			11					
				–	–		–	

802 OUTSIDE CONTROL.

N.E.M.E. Co. Ltd., Wallsend Laboratory. Date. 31st July 1914 Signature J.R.D.

SUBJECT		DATA.	
CASTING ...	Name & Number	H.C.4.E. H 214	Jobbing
,, ...	Other details ..		
LADLE ADDITIONS	per 1000 lbs.		
,, ...			
TEST BARS ..	Time cast ..	4·1	5·15
,, ..	Number or Type	2 Transverse	2 Transverse
SKIMMING	Time started	4·3	5·16
,,	,, finished .	4 Y	5·19
POURING .	Time started 1st ladle ..	4·11	5·25
,, .	,, 2nd ladle	—	5 28
,,	Temperature	1215	1200
,,	,,	1205	1190
,,	,,	1190	1190
,,	,,	1185	1180
,,	,,	1180	
,, ...	Time finished 1st ladle ..	4·14	—
,,	,, 2nd ladle .	—	—
FEEDING .	Time started		—
,, ...	,, finished ...		—
REMARKS ...			
,, ...			

TOTAL WEIGHT OF METAL CHARGED = 34,000 lbs.

,, ,, ,, TAPPED = 32,480. lbs. (14 tons 10 cwts.)

,, TIME FROM BLAST ON TO END OF LAST TAP = 3 hrs. 54. mins.

MELTING LOSS = 4·47 %. RATE PER HOUR = 8328 lbs.

Specimen pages of Outside Control Records used in the North Eastern Marine Engineering Company's Laboratories. (*See page* 29.)

INSTITUTE OF MARINE ENGINEERS.

The twenty-sixth annual dinner was held in the Grand Hall, Hotel Cecil, on Friday, December 2. The President, Sir Joseph Paton Maclay, Bart., was in the chair, and a most enjoyable evening was spent. There were more than 600 diners present. Interesting speeches were given by Lieut.-Gen. Sir Travers E. Clarke, K.C.B., K.C.M.G., D.S.O., Rear-Admiral Murray F. Sueter, C.B., M.P., and Vice-Admiral Sir George G. Goodwin, K.C.B., R.N., in reply to the toast of "The Imperial Forces," proposed by Sir Chas. J. O. Sanders, K.B.E.

Sir Joseph Maclay, in proposing the toast of "The Shipbuilding and Shipping Industries," said that probably there never existed in the history of the industry such a condition of anxiety as at present prevailed. At the end of the war high freights ruled and shipowners were willing to pay almost any price to obtain tonnage. The whole world seemed to lose its equilibrium when this bubble burst. In reply, Sir Archibald Denny, Bart., LL.D., said that it was not possible to be a pessimist and a shipbuilder, and although we were experieneing a bad time and he could see no light ahead, consolation could be taken from the fact that we were at the bottom of the depression.

Sir Owen Philipps, G.C.M.G., M.P., in a short speech, warned everybody to be on the alert or we would be left behind by the foreigners in marine engine developments. Many big problems still faced us with regard to the Diesel engine. What we wanted was an engine with twice the power with half the weight of the present designs.

THE BEARDMORE-TOSI MARINE DIESEL ENGINE.

First Large Installation; now fitted in a Single-Screw Cargo Steamer of 2,000 Tons D.W.

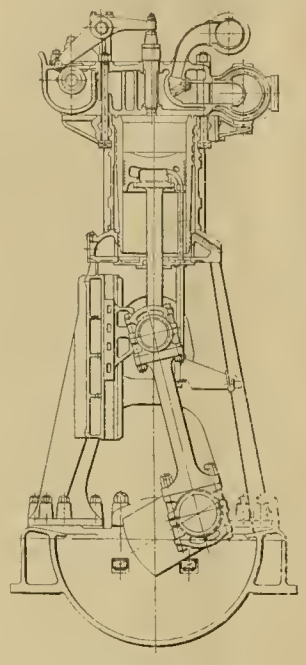
Some time ago the well-known Clyde firm of William Beardmore & Co., Naval Construction Works, Dalmuir, commenced the construction of marine Diesel engines of a design embodying the principal features of the engine developed by the Italian firm of Franco Tosi, of Legnano, Italy, which they have therefore called the Beardmore-Tosi type of marine Diesel engine. The first large unit of this type constructed at the Dalmuir works has now been installed in a single-screw cargo vessel of about 2,000 tons d.w. capacity, built by the firm for the fruit-carrying trade. The fitting of Diesel engines on vessels of this type has the advantage that it obviates the possibility of damage to perishable cargo such as fruit, wines, &c., from the heat generated by boilers.

Before installation into the vessel the engine was subjected to an exhaustive series of trials on the test-bed, under the direction of Mr. James Richardson, B.Sc. Of these tests, which proved highly satisfactory, we are able to publish some of the more important data, much of which has not hitherto been made public.

General Description of Engine.

The engine is of the four-stroke cycle, single-acting, marine crosshead type, developing 215 b.h.p. in each of its six cylinders when running at 125 r.p.m. Each cylinder has a bore of 720 mm (24 $\frac{7}{16}$ in.), the stroke being 975 mm. (38$\frac{3}{8}$ in.), giving a very moderate piston speed of approximately 800 ft. per min. The mean effective pressure on a brake horse-power basis is 75 lb. per sq. in. and 97 lb. per sq. in. on the indicator cards. The speed of revolutions can be reduced to 28 per min. with all cylinders firing, giving a range of speed of from 130 to 28, or 4·65 to 1.

The main bearing housings are of circular section to permit of easy removal of the bottom half bushes. The guides are detachable and carried on one side of the columns only, allowing easy accessibility for the inspection of the crosshead bearings, and telescopic tubes for the piston cooling gear. Provision is made for water circulation through both the ahead and astern guides. The crankshaft is of the solid forged type in three sections and is drilled axially through the journals and crankpins and radially through the webs for forced lubrication to all the bearings.



Sectional View: Beardmore-Tosi Marine Diesel Engine.

Fresh water cooling is provided for the piston, the gear being of the telescopic type consisting of two pipes, one inlet and one discharge, attached to the piston. In the cylinder head are the following valves:—(*a*) Air starting valve; (*b*) relief valve; (*c*) fuel injection valve; (*d*) two combined inlet and exhaust valves; (*e*) two "director valves." The valves (*d*) operate together and function alternately as suction and exhaust, in conjunction with an oscillating semi-rotary valve or "director-valve" which is driven by an eccentric so as to place the communication passage with the interior of the cylinder into connection with either the induction or exhaust manifold as shown in the drawing above.

It will be seen that the combined inlet and exhaust valves in the cylinder head are exposed to the heat of the exhaust gases, but immediately afterwards are cooled by the incoming charge of cold air, which also tends to clear the faces of any soot or deposit that may be lying on it. The "director" valves are fitted in each cylinder head, there being one for each combined inlet and exhaust valve. These director valves do not rub on any surface, so they cannot seize, and in addition they require only infinitesimal power for their operation.

Manœuvring and Reversing.

The fuel injection valve, which is shown on page 37, is of the needle type, and so designed to eliminate all packing glands. The valve stem is squared at its upper end and provision is made to permit of grinding-in the valve in place without dismantling any of the valve gear. The fuel valve, starting air valve, and the combined inlet and exhaust valves

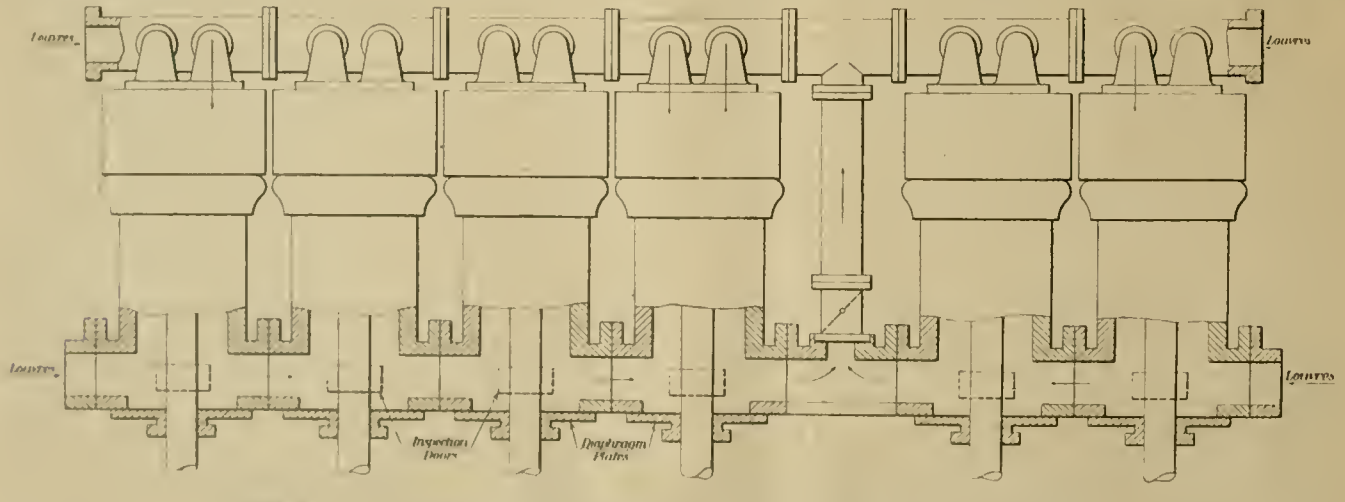
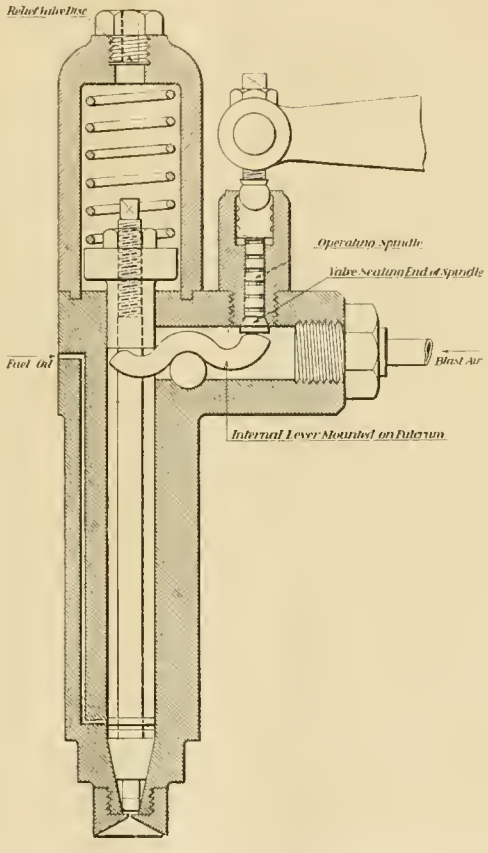


Diagram of Air-Induction System of Beardmore-Tosi Marine Diesel Engine.

are operated by means of rocker levers mounted on a fulcrum shaft, and by cams arranged on the camshaft which is mounted at the top of the cylinders. For reversing the engine there are the ordinary double cams—one for ahead and one for astern running—but instead of moving the camshaft bodily the cam rollers only are moved to register with their required cams, a light shaft directing this movement of the rollers. When reversing, the fulcrum shaft is rotated until all the rollers are clear of the cams, when a gate in the reversing disc is opened for the passage of a steel finger connected with the light shaft directing the movement of the rollers. The fulcrum shaft is operated by means of an electric motor or in emergency by hand, thus conserving starting air. The manœuvring gear is of the " all round " type.

The engine starts up in the following sequence: Six cylinders on air, three cylinders on air and three on fuel, six cylinders on fuel. Fuel, starting air and blast air are automatically " cut in or out " when stopping or starting, while suitable locking arrangements are also provided for the reversing gear. The control and manœuvring can be made entirely by one man, all the valves for the blast air and starting air, as well as connections with auxiliary generator engines and auxiliary compressor, being conveniently placed within reach of the manœuvring position.

Fuel is supplied to each cylinder by an independent pump, while the six pumps are grouped together in one forging, mounted horizontally on the front of the engine and driven by the vertical intermediate shaft, the function of which is to operate the cam shaft. Each pump is fitted with one suction and two delivery valves. Speed control is effected by altering the timing of the suction valves in the usual manner. Compressed air is used for fuel injection and is supplied by two three-stage air compressors driven from the forward end of the crankshaft. Each compressor is made as an independent unit and is capable of running the engine at full power.



Diagrammatic Section of Beardmore-Tosi Patent Fuel Injection Valve.

Trial Results.

On the test-bed this engine was run for over 250 hours. During this time the following trials were carried out:—

(1) Six hours' trial at 1,332 b.h.p.
(2) 100 hours' non-stop trial at 1,267 b.h.p.
(3) Manœuvring trial extending over one week.

Six Hours' Trial.

B.H.P.	1,332.
I.H.P	1,766.
Mechanical efficiency	75·5 per cent.
Revolutions per minute	129·6.
Mean pressure on b.h.p. basis	76 lb. per sq. in.
Fuel consumption	·411 lb. per b.h.p. per hour.
Blast air pressure	1,030 lb. per sq. in.
Exhaust invisible.	

100 Hours' Trial.

Average b.h.p.	1,267.
Average i.h.p.	1,646.
Mechanical efficiency	77 per cent.
Revolutions per minute	124.
Mean pressure on b.h.p. basis	75·5 lb. per sq. in.
Fuel consumption	·42 lb. per b.h.p. per hour.
Lubricating oil consumption, total for cylinders and loss	4 to 5 gallons per 42 hours.
Exhaust temperature. Average at exit from exhaust valve	550° Fahr.
Lubricating oil pressure	10-12 lb. per sq. in.
Circulating water pressure (jacket)	10-15 lb. per sq. in.
Piston cooling water pressure	20-30 lb. per sq. in.
Water temperature at outlet from cylinder heads	125° Fahr. average.
Piston cooling water outlet temperature	130° Fahr. average.
Blast air pressure	1,000 lb. per sq. in.

The engine ran steadily throughout the trial, and at the finish was reversed and run astern for 10 minutes, the time from full ahead to full astern being eight seconds, while by hand the engine can readily be reversed in 25 to 35 seconds. Throughout the trial the engine operated without noise and with an invisible exhaust.

All the above trials were carried out without a single valve, piston ring, or any other " Diesel " part requiring examination or attention.

On dismantling the engine before installing on board the vessel, all parts were found to be in excellent condition. All piston rings were free in their grooves and there was no indication of carbonised oil or gumming. No pitting was present on any of the valves, and only a thin coating of fine carbon was found on the exhaust passages, the " director " valve and exhaust pipe. The top of the main pistons and bottom of the cylinder covers were quite clean. The slight amount of carbonised oil collected on the trays under the main pistons isolating the cylinders from the crank chamber was semi-fluid, and its composition indicated slightly excessive lubrication of the main pistons. All the bearings showed a good bearing surface.

Fuel Injection Valve.

The fuel injection valve for the Beardmore-Tosi engine is of a novel design, and further particulars will be of interest. It is designed to give certainty of action, thus eliminating the troubles often met with in the " gland " type of valve. These include the possibility of the valve spindle being hung up due to a too-tightly packed gland, and consequently heavy charges passing into the cylinder; the scouring of the spindle due to the pressure of the stuffing-box packing, resulting in the loss of fuel at the gland; the risk of explosion inside the valve due to the valve being hung up, and the burning of the valve, as often happens when a tightly-packed gland causes the spindle to hang up, or to be sluggish in action.

As will be seen from the diagram above, the needle valve itself is operated through an internal lever pivoted on a fulcrum. This internal lever serves to reverse the direction of motion given by the operating spindle and to give an inward opening valve.

During the fuel injection period, the main valve lever, operated by the cam on the cam-shaft of the engine, depresses the operating spindle, and the valve face on its lower end is momentaneously off its seat, any leakage of oil during this period, which is only for some 40 deg. out of the 720 deg. of the cycle, being impossible owing to the remoteness of the

spindle from the fuel in the valve. It has also been found in operation that there is no leakage of air during this period, the ground plunger, which is supplied with lubricating oil grooves, being quite effective in preventing this. The internal pressure of air inside the valve keeps the operating spindle on its seat during the period in which the injection valve is closed, so that there is no loss of blast air. The main body of the valve is of high grade cast iron. The upper part containing the spring is of cast steel, and has on its top a disc of brass arranged as a relief valve. Should the pressure of the blast air inside the valve rise above the test pressure of the castings the disc will burst. The valve spindle is squared at its upper end and provision is made to permit of grinding-in the valve in place without dismantling any of the valve gear.

The fuel duct down the body of the casting leads the oil into the valve above the pulverising plates and cone; a small channel of 2 mm. in diam., however, passes into the small space surrounding the spindle below the cone. This small charge of oil has been found to be advantageous when fuel of high specific gravity or tar oil is being used.

As has been noted in describing the Beardmore-Tosi inlet and exhaust system, the "director" valve places the interior of the cylinder into connection with the air inlet passage as the piston passes over the top centre at the beginning of the induction stroke.

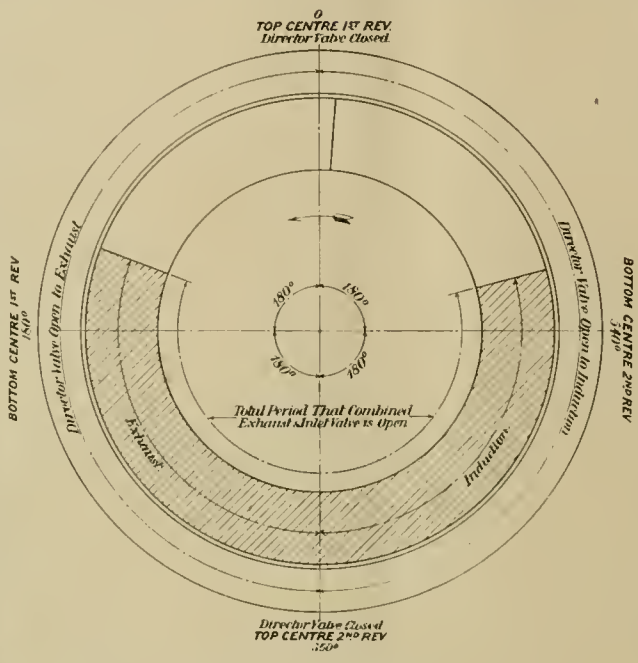


Diagram of Complete Cycle—Two Revolutions on Crankshaft Basis.

This induction air passage in each cylinder head connects direct to a light sheet steel manifold which runs the whole length of the engine which is placed immediately above the exhaust pipes. At each end of this manifold is a grid, and at about its centre is a pipe leading to the common chamber at the base of the cylinders. This chamber connects with the underside of all the pistons and is totally enclosed except for a louvre fitted in the base of the foremost and aftermost cylinders, and the pipe connecting with the induction manifold. This pipe, therefore, scavenges the space under the pistons of the engine, and should there be any blow past the piston rings due to wear at any time, this escape does not vitiate the atmosphere in the engine room, but is drawn up into the induction manifold.

The undersides of the pistons are separated from the crank chamber below by light cast-iron diaphragm plates in which glands are fitted for the passage of the piston rods and the telescopic tubes of the piston cooling gear. At the base of each cylinder at the back a small inspection door is fitted to ascertain the condition of the pistons, and the glands of the telescopic tubes for the piston cooling water, the arrangement being as shown in the diagram on page 36. This system makes for very silent operation.

The Beardmore-Tosi inlet and exhaust arrangements, as already mentioned, comprise two valves in the cylinder head as is normal with four-cycle engines. Two valves instead of one, which would be a possible arrangement with the Beardmore-Tosi system, are adopted in order to obtain perfect symmetry of design of cylinder head.

The cycle of operations will be readily followed from the diagrams reproduced below, the four strokes being as follows:—

First stroke.—At the top centre the "director" or flap valve is moved over by an eccentric driven from the cam shaft, and the two valves remaining open are thus put into communication with the air inlet pipe. The down stroke of the main piston draws air in over these two valves, and at the end of this stroke near the bottom dead centre both the valves close.

Second stroke.—The next stroke is the compression stroke preparatory to the injection, ignition and combustion of the fuel on the power stroke.

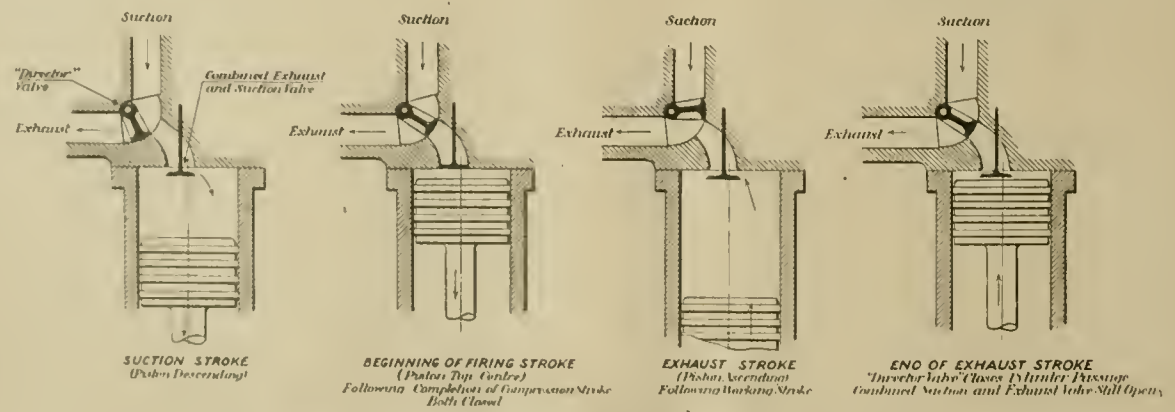
Third stroke.—The third stroke is the main piston power stroke at the end of which, near the bottom dead centre, both valves open.

Fourth stroke.—On the subsequent up or exhaust stroke the exhaust gases are forced out by the main piston through these two valves into the exhaust pipe.

Expressed on a crankshaft basis, one revolution representing 720 deg., the timing of the valves is shown on the diagram above. It should be noted that the director or flap valve does not require to be reversed for running astern and is entirely free.

Since two valves serve for either function of inlet and

(*Continued on page* 42.)



Beardmore-Tosi Marine Diesel Engine—Cycle of Operations.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Reform of the Technical High School.

In a very lengthy article the author goes into the whole question of technical education. He condemns the onesidedness hitherto existing and insists upon a more general education and improved method of education. His recommendations are briefly as follows: Careful choice of teacher, selection of students according to ability, revision of teaching through collaboration, &c., and the more extensive adoption of the seminar method of education. The article contains much valuable criticism.—*F. Romberg, Schiffbau, J.* XXII.

Determination of Angle of Heel in Inclining Experiments.

In carrying out an inclining experiment error is most likely to occur in the determination of angle of heel. This is due to the unsteady motion of the pendulum, and the possible want of rigidity of the ship. For the accurate application of the metacentric theory only very small inclinations, and hence small inclining weights, are required. But very small inclinations are outside the sensitivity of the usual pendulum and the author recommends the use of a theodolite on the ship and batten on the land. Here great sensitivity may be obtained. To test whether any tendency to twist is present during inclining, sights should be made and thus the reliability of the theodolite reading ascertained.—*G. Schultze, Schiffbau, J.* XXII.

The Wind Propulsion of Cargo Vessels.

There is undoubtedly a distinct movement—almost world wide—towards the scientific resuscitation of the sailing vessel. The author, who is the chief engineer to Schneider & Co., considers the problem fundamentally although perhaps a little too much in the abstract. He briefly disposes of the older theories of the sailing ships, and after superficial analysis sets up relations which exist between angle of wind, form of ship, and drift angle. The trend of the development is certainly obscured through lack of diagrams, but the author goes on to show that the sail does not offer much hope of improvement and considers that the hull itself presents the greatest possibilities. Instead of altering the set of sails for each change in wind direction, it is suggested that some form of hydroplane be fitted as in submarines, &c., in order to correct the drift angle effect. Such a mechanism has not to interfere with the ahead resistance of the ship, and the author intends to show in a future article how this can be done. The article, which is typically French, is an interesting contribution to the subject.—*P. Drosne, Bull. Tech. du Bureau Veritas*, Vol. III.

Time, Piece and Premium Systems of Payment.

Time and piece rate systems are first reviewed in a fundamental light. The disadvantage of the former is lack of incentive to the worker, and of the latter, restriction of output due to fear of rate cutting. The variation in complete cost of work to the employer, and in the hourly remuneration to the worker, as the latter completes his work in different times less than a basis, is shown both mathematically and graphically. The author next sets out to deduce a premium system, which satisfies the fundamental condition of small complete cost to employer, and larger hourly pay to worker. The system which increases the worker's hourly rate by the same percentage as hours saved by him is first considered. This system is shown to necessitate harder work on the part of the worker, in order to earn the same amount as under piece-work conditions. Before the revolution in Germany, piece-work was considered satisfactory by both parties; after it, however, great reduction in output took place, and concessions were extorted by means of which a man was paid piece-rate wages when not actually on piece-work, thus thereby doing away with the incentive. The author in view of the labour attitude considers that the above premium system would not be entertained by the workers and suggests a modified form which may be adopted. This consists in increasing the hourly pay by the percentage hours saved as before and in addition by this percentage squared. This system compares more favourably with piece-work rates. It is quite common in many German works, and the author concludes by recommending its general adoption.—*Frydrychowicz, Schiffbau, J.* XXII.

Rebuilding the German Mercantile Marine.

This article, of some length, forms an able and spirited attack upon the classification society control of the structural design of merchant ships. Germany having to rebuild her fleet almost *ab initio*, the author investigates the soundness or otherwise of the classification societies' requirements. Most of his remarks refer to the "English Lloyd's," and to the whole extent of structural design. The basis for the substitution of single and double angles is dealt with after which the designs of single and double bottoms are considered. Next the design of stem and stern posts is gone into. Transverse framing, stringers and deck beams are then considered with remarkable skill and thoroughness. Bulkheads, their stiffeners and brackets are discussed upon the usual method of analysis, but with an absence of doubtful assumptions which is refreshing to the technical reader. The question of brackets is next taken up generally, together with a complete treatment on rivet stress. The shell next receives attention, and finally the strength of erections examined. Throughout the article the author points out that many of the requirements of the classification societies are quite opposed to what science and even common sense would deem necessary. The author, one of Germany's ablest experts on the strength of ships, expresses the hope that the industry will ultimately be freed from the fettering influence of the classification societies.—*J. Stieghorst, Schiffbau, J.* XXII.

The Organisation of a Small Shipyard.

The article concerns a small yard where only twenty men are employed under one foreman. The author's aim is to outline a simple system whereby all costs may be recorded with the minimum of clerical work, and without the engaging of extra staff. The principle of the system is the converting of the existing clerical work to admit of a complete survey of the position of work in hand. A weekly wages card is supplied to each man, upon which he writes each day the number of hours he works on a particular job. In such a small yard a storekeeper cannot be afforded, and each charge-hand, when drawing from the store, makes a note on a special form of the nature, the size, and weight and purpose of the item, the daily total of such items being noted. Each week the wages cards are collected and the wages calculated. At the same time a third card is used for each particular contract, and the amount of wages and material to be allocated is at once transferred from the material and wages cards. This transference should not occupy more than twenty minutes daily for material, and an hour and a half weekly for wages. A final card is devoted to the quarterly assessment of establishment charges, and this used in conjunction with the particular contract cost card enables the financial postion to be readily seen. The system is quite a practical and certainly an economical one for small shipyards.—*H. D. Brasch, Der Kleinschiffbau, J.* 1.

Preservation of Wood for Shipbuilding.

After a preliminary survey of the methods developed principally by the British Admiralty since 1700 for the prevention of decay in wood due to fungi, worms and dry rot, the author quickly comes to the present-day use of creosote. In shipbuilding, its use is restricted to wood lifeboats, &c. The case of two pontoons, one impregnated with creosote (the cost of which was 5 per cent. of the total cost), and another of ordinary pitch pine is mentioned. The first has been in continuous service since 1900, while the life of the second is estimated to be only 10 years and its cost of upkeep more than balances the initial expense of the first.

In ordinary steel ships wood is still preferred for accommodation, store room linings, &c. For these purposes creosote preservation

cannot be used and an impregnation with a salt solution is recommended. In America a solution of copper sulphate in mercury chloride is successfully used for yachts and small boats. Where it is impracticable to impregnate all wood then only those portions subject to alternate wetting and drying should be treated.

The actual means of carrying out this process is described and illustrations of the plant of Kupsch & Seidel, of Stolpmünde, are shown. Considerable research has been carried out by the German post office authorities on this subject, and their findings can be utilised for the benefit of the shipbuilding industry. The author concludes by recommending the creosoting of all wood not in contact with perishable cargo, and for internal work he recommends the improved cyanide process.—*Dr. F. Moll, Schiffbau, J.* XXIII.

Graphical Quadrature.

The chief recommendation for purely graphical means of obtaining areas lies in the small amount of brain work they require through their mechanical nature, and the fact that they do yield the same order of accuracy as the approximate numerical methods. The author gives several ingenious graphical methods of obtaining the mean ordinate of curves and shows directly how the graphical construction compares with the fundamental assumptions of Simpson's first and second, and the trapezoidal rules. While it is quite impossible to outline the method in detail in this short review, it is of interest to note that the construction is applied to the construction of Bonjean curves, calculation of displacement, centroids and centres of buoyancy. The article concludes with an extension of the principle to the calculation of metacentric radii.—*Dr. H. Schultz, Schiffbau, J.* XXII.

Application of Diesel Engines to Deep-Sea Trawlers.

In the past the steam engine has held its own for trawler work, but for sailing fishing vessels the auxiliary motor is firmly established. With the present increase in cost of coal the Diesel engine does become more feasible. A comparison of steam and oil installations of equal cost is given, and in the case of a forty-metre trawler an increase of 50 per cent. in the size of the fish hold and a slight increase in speed is given by the Diesel installation. For auxiliary purposes an oil-fired donkey boiler is retained in the new design, the necessary oil fuel for main and auxiliary machines being carried in the double bottom. Instead of donkey boiler, &c., electric auxiliaries could be fitted, but in this case there is no means for utilising the exhaust gases from the motor as in the former. The Daimler six-cylinder submarine Diesel is recommended, of 420 h.p. and 375 revolutions. In order to maintain constant revolutions a patent propeller having adjustable blades, the pitch of which is controlled from the bridge, is recommended. By this propeller it is claimed that any intermediate ahead speed may be obtained and that ships may be reversed in about 10 seconds without interfering with the main engine. The author concludes by recommending some trawler owner to convert an existing steam installation in order to definitely establish the efficiency of the Diesel drive.—*Wölke, Schiffbau, J.* XXII.

Development of Floating Docks.

After considering the subject of docks generally, the author quickly proceeds to the study of the "U" shaped floating dock. The problem of the increasing of the useful life of docks is first dealt with, a very full description and criticism of the means adopted in existing types towards this end being given. Next the subject of the economic construction and working is treated at some length, and the various types and patents again contrasted by considering, in detail, alternative designs for a dock of 3,700 tons lift. The advantages of compressed air installations are reviewed as applied in the various existing systems. Considerations affecting scantlings and practical constructions are briefly generalised. Coming to the question of economy in working, the author reviews the possible improvement in the direction of simplified machinery by Diesel motor and electric installations, &c.; simplification of docking methods and reduction of men employed. Means of expediting and facilitating work are considered, and finally the extraneous application of floating docks, such as for salvage purposes, dealt with.—*W. Stiller, Schiffbau, J.* XXII.

Electric Heating of Rivets.

The enormous amount of riveting necessary in all branches of structural engineering is responsible for a large consumption of coal; and it has been estimated that for every ton of rivets heated, one and a-half tons of coal are required. The present need for fuel economy directs attention to the possibilities of electric welding, and hence to the electric heating of rivets. The ordinary electric welding machine can be simply converted to heat rivets, but requirements of lightness, portability and simplicity demand a specially designed machine. Such a machine is built by the "Gesellschaft für Elektrotechnische Industrie" in Berlin, and it is fitted with all accessories for shipyard work. Three pairs of electrodes are fitted to each machine, and it should be noted that current is only used whilst a rivet is being heated—a considerable economy. The heating is always visible, and hence overheating is unlikely to occur. The hourly capacity of the heater is estimated to be 500 rivets of 10 mm. diam., 0·50 mm. length; 200 to 250 of 16 mm. by 70 mm.; and 100 to 120 of 22 mm. to 25 mm. by 70 mm. to 80 mm. The electric energy required to heat 100 kg. of rivets is about 50 k.w.h., and if the coal ordinarily required to heat 100 kg. were used to generate current, 150 k.w.h. could be obtained. The economy is obvious, and the author recommends the adoption of the machine for all forms of structural engineering.—*A. Hochstimm, Schiffbau, J.* XXIII.

A NEW WATER-TUBE BOILER FOR MERCHANT SHIPS. (*Concluded from page* 11.)

Suitable baffling is arranged to give the most economical results in the passage of gases through the tubes.

An experiment was made with the boiler worked with auxiliary feed make up from shore water which contained a large proportion of chalk and lime in solution and also from the sea water taken from the river, the density of the water being 4/32 after three weeks' continuous working. At the end of this period the boiler was opened up when all the deposit was found in the lower drums and nothing in the tubes. This characteristic should be a valuable one in the event of a split condenser tube.

Next in importance to the practical working of water-tube boilers at sea is the efficiency of steam production, and the trial results given on page 11 show what has been done.

The arrangement of the superheater element is such that by manipulating three stop valves this portion can be converted into a saturated steam producer either to supplement the total steam supply or as a precaution against damage to superheater tubes when lying under banked fires or when working engines in or out of port, *i.e.*, when little or no circulation obtains in the superheater tubes. The judicious use of this property should tend to a long life of the superheater tubes, coupled with the fact that experiment has shown that the temperature of the gases adjacent to the first row of superheater tubes never exceeds 900° Fahr. at the highest rate of combustion.

The whole of the heating surfaces can readily be cleaned of soot deposits by the use of the permanently-fixed diamond blowers at A B B.

As will be seen from the trial records, the boiler has been worked with oil fuel, but equally satisfactory results have been obtained with coal.

All the experiments shown were carried out under closed stokehold conditions with unheated air. This, however, if fitted in a vessel, would be modified and the air heated by adopting the Howden smoke tubes at base of funnel, with a corresponding increase in efficiency.

The weight of this boiler, complete with water, is from two to three times less than ordinary cylindrical boilers, depending, of course, on the rate of combustion adopted, with a corresponding reduction in space occupied. The cost of production of this boiler and superheater is less than the ordinary cylindrical boiler and superheater per pound of steam generated. The boiler illustrated is designed for an evaporation of 30,000 lb. of steam per hour, 200° Fahr. superheat, with about 2 in. of air pressure in the stokehold and engines using 15 lb. of steam per horse-power hour will equal 2,000 h.p. burning oil fuel.

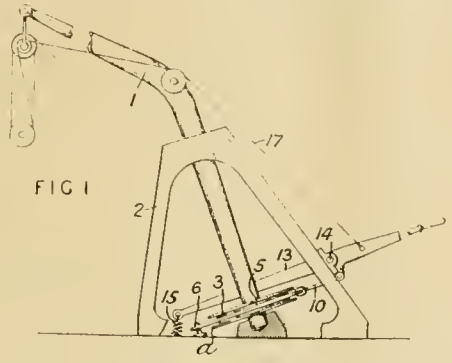
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 168,841. Ships' Davits.

Naamlooze Vennootschap Internationale Nautische Handel-Maatschappij, The Hague, Holland. November 3, 1920, *No.* 31101. *Convention date, September* 7. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 115.]

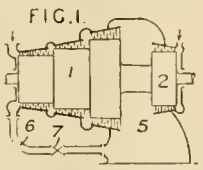
A davit 1 adapted to swing outboard by gravity or the weight of the boat is fitted with means to prevent swinging, such means automatically tending to move and to remain in the operative position. The davit 1 is fitted with a brake drum 3 associated with diametrally opposed brake shoes 5 pivotally mounted on links *a*. The links *a* are mounted at one end on pivots 6, and coupled at the other end to a link 10 pivoted on the lever 13. The lever 13 is pivotally mounted in a bracket 14 on the davit frame 2 and is held in the operative position by a spring 15 or counterweight. The fall 17 may be coupled to the lever so that the braking force is increased due to the weight of the boat when freely suspended. Specification 149,175 is referred to.



No. 168,946. Turbines.

H. L. Guy, Trevethin, Albany Road, Victoria Park, Manchester, and Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster. May* 10, 1920, *No.* 12925. [*Class* 110 (iii).]

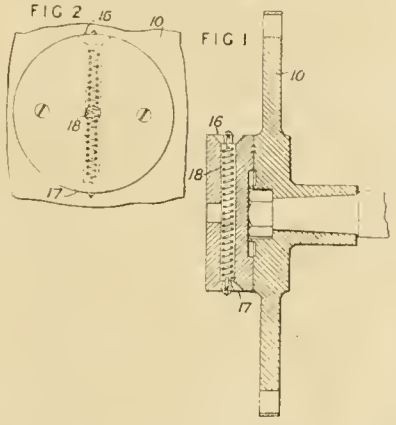
In steam turbines, wherein some or all of the moving blades of a section or element are unsymmetrical, special pipe connections are provided so that the pumping action of such blades, which occurs when the section is rotating idly and in the opposite direction to its normal one, is utilised to provide a continuous circulation of cooling steam through the idly-running sections in a direction opposite to that in which the driving steam is caused to flow. For example, in a turbine having forward and reverse turbines, 1, 2 of the reaction type on the same shaft, a valved pipe 6 connects the inlet end of the turbine 1 with the exhaust casing 5 so that when the reverse turbine 2 is being normally operated and the ahead turbine 1 is rotating idly, the pumping action of the turbine 1 causes steam to circulate therethrough from the exhaust casing 5 to the inlet and back through the pipe 6 to the exhaust casing, the valve 7 being opened for that purpose. For cooling the reverse turbine when running idly, similar means may be provided, or leakage steam may be used or the means described in specification 131,428. The steam led away from the idly-running turbine section may in some cases be led to the exhaust of another turbine, or to a feed-water heater, or to a low-pressure stage to do work. The cooling steam supplied to the idly-running section may be drawn from a low-pressure stage or the exhaust of another section. Specification 135,102 also is referred to.



No. 168,869. Turbines.

Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster.*—(*Assignees of W. B. Flanders,* 27, *Jansen Avenue, Essington, Pennsylvania, U.S.A.*) *August* 4, 1921, *No.* 20779. *Convention date, September* 4, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 103 (i) *and* 110 (iii).]

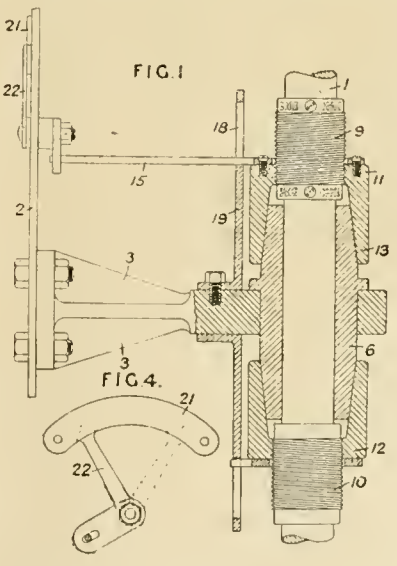
To prevent over-speeding of a turbine 10, a centrifugal pump 18 is attached to the turbine rotor and provided with spring-connected valves 16, 17 which are adapted to open antomatically when a certain speed is reached and render the pump operative, thereby imposing a load on the turbine. In a modification, the centrifugal pump is a hollow perforated drum with leaf springs covering the perforations.



No. 168,971. Locking Shafts in Predetermined Positions.

Swan, Hunter, and W. Richardson Limited, Wallsend Shipyard, Wallsend-on-Tyne, and J. F. Holdcroft, 17, *John Street, Cullercoats, both in Northumberland. June* 8, 1920, *No.* 15495. [*Classes* 65 (i) *and* 135.]

The shaft 1 for operating a door, barrier, valve, or other movable member is adapted to be secured or locked in a predetermined position by means of one or more slidable cones 12, 13 formed as nuts engaging oppositely threaded portions 10, 9 respectively of the shaft, rotation of the shaft in one direction bringing the coned nuts into engagement with a double-coned member 6 mounted on a bracket 3. Rotation of the shaft in the other direction moves the nuts apart to allow the shaft to be moved freely for operating the door or other member to which this shaft is connected. Fig. 1 shows the bracket 3 carrying the split-coned member 6 as secured to a bulkhead plate 21, the shaft being operatively connected to a bulk head-door. The nuts 11, 12 have projections secured thereto and engaging slots 18 in a plate 19. The upper projection 15 is formed as an arm arranged to engage a pointer 22 movable over a dial plate 21, Fig. 4, which indicates when the shaft is in the locked position. The members 9, 10 and indicating pointer are adjustable so that the door may be locked in the open, closed, or intermediate position. By providing both of the screwed sleeves 9, one of two rolls A is arranged at the bottom of the unit. The webs from all the units may be led over guides 1 to associating mechanism 2 and a folder 3.

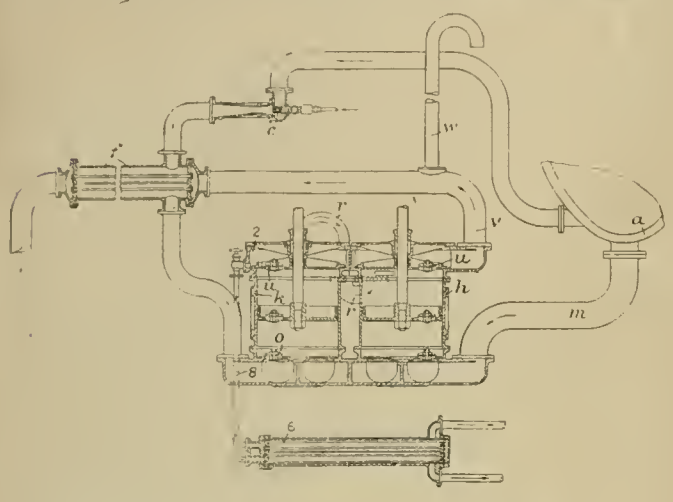


No. 169,084. Condenser and feed-water Plant.

G. and J. Weir Limited, and C. R. Lang, Holm Foundry, Cathcart, Glasgow. August 12, 1920, *No.* 23601. [*Classes* 32 *and* 64 (i).]

In plant with a main and a supplementary condenser and a Weir dual air pump, the condensate from the main condenser is delivered

to the "wet" barrel below the foot valves, the condensate from the supplementary condenser is delivered to the "dry" barrel beneath the foot valves, and the feed water is passed to the supplementary condenser as condensing water by the wet barrel. Air is drawn from the main condenser *a* by an ejector *c* to the supplementary condenser *f* and passes to the space beneath the foot valves *o* of the "dry" barrel *k* of the dual air pump. The condensate from the

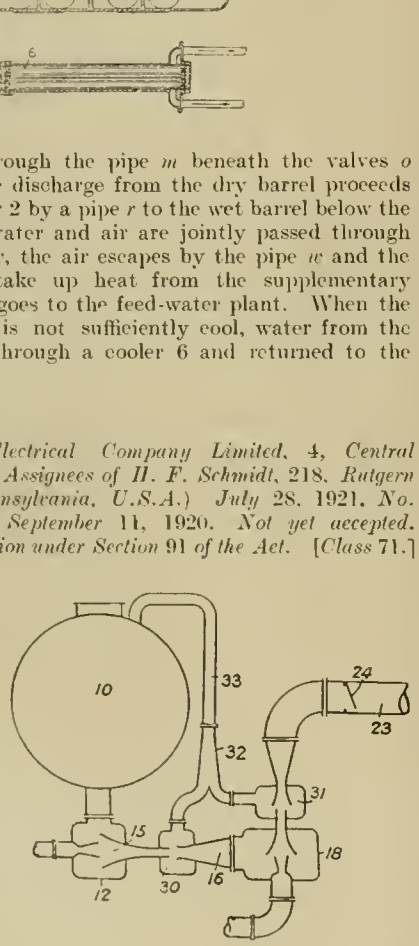


main condenser flows through the pipe *m* beneath the valves *o* of the wet barrel *h*. The discharge from the dry barrel proceeds from the delivery chamber 2 by a pipe *r* to the wet barrel below the head valves *u*, and the water and air are jointly passed through these valves to the pipe *v*, the air escapes by the pipe *w* and the feed water proceeds to take up heat from the supplementary condenser *f* and thence goes to the feed-water plant. When the feed to the dry barrel is not sufficiently cool, water from the space 2 may be passed through a cooler 6 and returned to the barrel at 8.

No. 169,146. Ejectors.

Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings*, *Westminster*.—(*Assignees of H. F. Schmidt*, 218, *Rutgers Avenue*, *Swarthmore*, *Pennsylvania*, *U.S.A.*) *July* 28, 1921, *No.* 20288. *Convention date*, *September* 11, 1920. *Not yet accepted*. *Abridged as open to inspection under Section* 91 *of the Act*. [*Class* 71.]

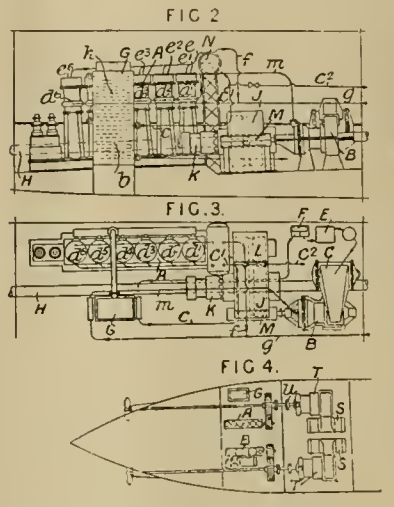
Condensate or hot-well ejectors comprise more than one stage and have overflows at the several stages all connected to the upper part of the condenser. In a two-stage arrangement, the first-stage ejector 12 is operated by exhaust or live steam, and from the overflow chamber 30 around the diffuser 15, 16, pipes 32, 33 lead back to the condenser 10. Similar overflow connection is provided for the overflow chamber 31 of the second-stage ejector 18. Live or exhaust steam is used for the second stage, and the usual check valve 24 upon the delivery 23 is provided.



No. 169,275. Propelling Ships.

W. Schmidt, 2, *Rolandstrasse*, *Wilhelmshohe*, *Cassel*, *Germany*. *June* 22, 1920, *No.* 16883. [*Classes* 7 (ii), 64 (i), 110 (iii), 114, 123 (ii), *and* 123 (iii).]

Relates to cruising plant for warships, and consists in using an internal-combustion engine and steam engine wherein at low speeds the steam for the engine is obtained from the exhaust and water-cooling systems of the reciprocating engine, which steam is progressively supplemented by boiler steam as the speed is increased. For full speed, main turbines are employed, and the cruising plant is closed down. The cylinder jackets are connected to a common collecting drum from which the steam is drawn for the engine. The plant comprises a propeller shaft H on which is freely mounted a pinion J with claw coupling K, Figs. 2 and 3, the pinion J being driven by an internal-combustion engine A through a wheel L and by a turbine B through a wheel M. A feed pump F draws from a feed-water tank E, which is supplied from the condenser C and delivers the feed water to a coil *b* in the exhaust-gas heater G, from which the water goes by the pipe C^1 to the drum N by the pipe C^1 or by the pipe C^2 to a boiler. From the vessel N, the water passes to the bottom of the water-jackets d^1, d^2, d^3, d^4, d^5, d^6 up through the jackets, thence by steam pipes e, e^1, e^2, e^3, e^4, e^5, e^6 to the top of the drum N. The steam pipe *f* from the drum and steam pipe *g* from the boiler are coupled to superheating coils *k* in the exhaust-gas heater G, from which the steam pipe *m* goes to the turbine B. The disposition of the plant in a ship may be varied: in one arrangement the main turbines T and condensers S, Fig. 4, are arranged in a forward compartment, and the cruising plant is placed aft. In cruising, one shaft is driven by the internal-combustion engine A and the other by a reciprocating steam engine B, which utilises the waste heat of the engine A, G being the waste heat unit and C the condenser. Clutches U are provided for cutting out the main plant when cruising.



Beardmore-Tosi Marine Diesel Engine.—(*Concluded from page* 38.)

exhaust it is obvious that each is only of half the normal area and size, and thus the uncooled and unsupported portion of the cylinder head is only 15 per cent. of the total area as compared with 28 per cent., which is usual. Hence the cylinder head is at a lower temperature and is considerably less stressed. Moreover, the valves being smaller, they run at a lower temperature. The diameter of valve for a $24\frac{3}{8}$-in. diam. cylinder is only $6\frac{7}{8}$ in. as compared with the normal of 9 in. diam. of the usual inlet and exhaust valves. The director valve system furthermore ensures that at each cycle the valves are swept by the cool incoming air, so nullifying in measure the heating effect of the exhaust gases. The results of these two factors, firstly, small valves and the cooling effect of the current of induction air, are that the valves run at very low temperatures, approximately half the usual figure, and furthermore, any carbon that might lodge on the valves is swept off by the induction air that passes into the cylinder immediately following the exhaust outlet. On account of these facts the re-grinding of these valves need only be undertaken at long intervals. The duty to which the exhaust valve is subject is much less onerous than has hitherto ever been the case. In fact, it is no exaggeration whatsoever to state that their functions are simplified and eased to the extent of 75 per cent.

Again, the small valves and the extremely slow motion go far to make possible the remarkably silent valve operation which characterises this engine and which has been so favourably commented upon. Not only is the cylinder head cooler as a whole, but is not subjected to the usual unequal stresses where the one side is kept cool by the incoming air and the other is heated by the hot outgoing exhaust, so tending to distortion.

The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION CARGO HANDLING APPLIANCES

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Mr. Summers Hunter, Junior, has been appointed a Director of the North Eastern Marine Engineering Company Limited, Wallsend-on-Tyne and Sunderland.

Cork Harbour Commissioners have appointed Mr. M. B. Conlan, Principal of Cavan Technical School, to the new position of Superintendent of the Harbour, with a view to the reorganisation of its working.

Mr. Michael J. Watkins has been appointed General Manager and Secretary to the Harbour Commissioners of Belfast in succession to Mr. D. J. Owen, who has become General Manager to the Port of London Authority, and his appointment was confirmed at a meeting of that body on January 17. He is a Liverpool man, 45 years of age, and before becoming Assistant Secretary of the Humber Conservancy Board was engaged in the office of the General Managing Secretary to the Mersey Docks and Harbour Board.

Mr. William Denny, of the firm of William Denny & Bros. Limited, engineers and shipbuilders, Dumbarton, has joined the board of the Still Engine Company.

The Booth Steamship Company Limited announce that the personnel of the management of the company as from January 1 is:—General Manager, Mr. Frederick G. Heise: Manager, Mr. Jasper Moon; Technical Manager, Mr. C. K. Butler Stoney; Assistant Manager, Mr. Edgar B. Deyes.

Mr. Vivian Withy, Consulting Engineer of the firm of Cromar & Withy, marine surveyors, Middlesbrough, was found dead at the Star and Garter Hotel of that town, having apparently fallen from the window of his room. Mr. Withy was the eldest son of Mr. Henry Withy, one of the original partners of Furness, Withy & Co.

Mr. William Cocks, C.B.E., acting on medical advice, has resigned his position as Managing Director of the Cardiff Channel Dry Docks & Pontoon Co. Limited, and its subsidiaries. The board have regretfully accepted the resignation, but have unanimously elected Mr. Cocks to a seat on the boards of the Cardiff Channel Dry Docks & Pontoon Co. Limited, the Bute Shipbuilding, Engineering & Dry Docks Co. Limited, the Mercantile Pontoon Co. Limited, the Tredegar Dry Docks & Wharf Co. Limited, and the Barry Graving Dock & Engineering Co. Limited.

Captain J. C. Drummond, after 38 years' service, has retired from the position of Chief Marine Superintendent of the Pacific Steam Navigation Company. He was apprenticed to the old firm of W. J. Myers & Son, and his first ship was the *Cordillera*, sailing for Sydney in 1873. He made many voyages under the Pacific Steam Navigation Company's flag, until in 1893 he was appointed Assistant Marine Superintendent under Captain Conlan, who died in 1907, when Captain Drummond succeeded him. Thus in nearly 49 years Captain Drummond has served two firms only. He holds the M.M.S.A. medal for life-saving in connection with the wreck of the *Cotopari*.

Mr. Chas. J. Blackburn, Superintendent Engineer of the Isle of Man Steam Packet Company, has retired after 26 years' service. Mr. Blackburn served his apprenticeship with Laird Bros., and after going to sea for a while went as draughtsman to the Guion Line, becoming eventually Assistant Superintendent Engineer of that Line, under Mr. J. G. Hughes. During the 17 years he was with the Guion Line the well known "Atlantic Greyhounds" *Arizona*, *Alaska* and *Oregon* were built. In 1895 he was appointed Superintendent Engineer of the Isle of Man Steam Packet Company, and during his term of office the *Empress Queen*, *Viking*, *Ben-My-Chree*, *Snaefell*, and *King Orry* were built. Mr. Blackburn is succeeded by Mr. J. R. Kelly.

The General Committee of Lloyd's Register of Shipping, at their meeting on January 12, elected Mr. J. Herbert Scrutton as Chairman, Sir Thomas J. Storey, K.B.E., as Deputy-Chairman and Treasurer, and Captain H. B. Hooper, R.I.M., as Chairman of the Sub-Committees of Classification of the Society. Mr. Scrutton succeeds Sir John H. Luscombe as Chairman, the latter gentleman having expressed a desire to retire from office at the end of 1921. Mr. Scrutton, who is a partner in the old-established firm of Scrutton, Sons & Co., which was founded by his grandfather, was Chairman of the General Shipowners' Society for the year 1905-6, when he first took his seat on the Committee of Lloyd's Register, on which he has since served continuously. He was Vice-President of the Chamber of Shipping of the United Kingdom during the three strenuous years 1916 to 1918, and in that capacity rendered most valuable service to the Government and to British shipping. Mr. Scrutton would have been elected President of the Chamber at the end of his last year of office had his health at that time permitted. It is a remarkable fact that during the 88 years since the Society was reconstituted, in 1834, there have only been seven Chairmen.

EDITORIAL.

MARINE ENGINEERING TO-DAY.

TWO interesting publications have been issued by Lloyd's Register during the past month. These are the Quarterly Returns showing vessels under construction at December 31, 1921, and the Annual Summary of Output during last year. It is just a year since Lloyd's Register separated motor vessels from steam vessels in their figures, and it is now possible to give comparative statistics from September, 1920. The figures relating to the output of 1921 show that during the year 28 motor vessels of 102,356 tons were launched in the United Kingdom compared with 371 steamers of 1,429,757 tons. The great increase which was recorded twelve months ago in the use of steam turbines was continued during 1921, when 70 vessels with a total tonnage of 624,487 tons were launched, all being propelled with turbines and nearly all of the geared reduction type; with the exception of two of the vessels of 12,000 tons and upwards all the big ships are to be fitted with turbines. The biggest ship launched last year for Diesel propulsion was 9,500 tons.

Figures for countries abroad show there were 108 vessels of 204,286 tons being fitted with internal-combustion engines out of a total of 951 vessels of 2,803,627 tons launched during the year. Over 30 per cent. of the total world's output of steel steam tonnage last year will be fitted with steam turbines.

These figures, however, relate in some degree to the past, and it is more interesting to turn to the vessels under construction at the beginning of this year and to compare them with the position a year ago.

We have drawn up the following table showing the steam and motor vessels under construction in the United Kingdom quarter by quarter from September 30, 1920, and have worked out the percentage which these types present to the total building, which, of course, includes a small proportion of sailing craft. These figures show that at December 31, 1921, 92·8 per cent. of the tonnage related to vessels propelled by steam engines, 7·12 per cent. being propelled by internal-combustion engines. The table also shows a gradual ascendency of the motor ship since September 30, 1920.

Merchant Vessels under Construction in United Kingdom.

At:	Steam.		Motor.		Percentage tonnage of all types.	
	No.	Gross Tons.	No.	Gross Tons.	Steam.	Motor.
Sept. 30, 1920	871	3,514,475	50	205,661	94·2	5·5
Dec. 31, 1920	829	3,474,855	57	227,010	93·7	6·12
Mar. 31, 1921	791	3,539,364	66	263,180	93·0	6·93
June 30, 1921	715	3,284,912	57	241,003	93·1	6·83
Sept. 30, 1921	633	3,049,876	50	229,325	92·9	6·98
Dec. 31, 1921	472	2,450,283	37	188,396	92·8	7·12

The other table compares the steamships and motor ships building throughout the world at the two periods December 31, 1920 and 1921. Putting aside some of the small countries where only one or two ships are building as being of little significance, the figures relating to some other countries are very interesting. It will be seen that in Australia, Belgium, and Japan, Diesel engine ship construction has not been developed. Denmark, no doubt, by virtue of having the enterprising firm of Burmeister & Wain at Copenhagen, is well to the fore with Diesel engine construction, and the figures for Sweden show where very big and interesting developments in this direction are also taking place. The ratio of Diesel-engined ships building in Norway is comparatively high, but France, Holland and Italy are below the average. It appears from this table that taking all vessels recorded by Lloyd's Register as under construction at the end of last year, 91 per cent. are being built with steam engines, and 8·27 per cent. with internal-combustion engines. The practice of Lloyd's Register in regard to auxiliary ships is to classify them as steam or motor according to the type of auxiliary engine. As nearly all auxiliary engines are of the internal-combustion

Steamships and Motor Ships Building at December 31, 1920 and 1921.

		Steam.		Motor.		Percentage. Tonnage of all Types.	
		No.	Gross Tons.	No.	Gross Tons.	Steam.	Motor.
U.S.A.	1921	34	192,028	3	19,145	88·6	8·83
	1920	195	1,259,295	7	25,085	96·1	1·91
Australia	1921	9	15,150	—	—	81·0	—
	1920	6	19,990	—	—	85·0	—
Canada	1921	5	8,278	—	—	57·6	—
	1920	39	127,952	2	967	93·6	·7
Hongkong	1921	8	29,630	—	—	100·0	—
	1920	9	24,195	—	—	97·5	—
Belgium	1921	8	25,491	—	—	100·0	—
	1920	9	28,048	—	—	100·0	—
Brazil	1921	—	—	1	2,170	—	100·0
	1920	1	2,170	1	1,598	57·6	42·4
China	1921	6	6,050	—	—	100·0	—
	1920	17	49,292	3	4,332	91·9	8·1
Denmark	1921	19	32,645	8	30,420	51·7	48·3
	1920	40	76,228	16	44,671	62·9	36·8
Esthonia	1921	—	—	7	2,491	—	38·15
	1920	2	1,100	—	—	100·0	—
Fiume Dist.	1921	7	7,259	2	600	92·36	7·64
	1920	—	—	—	—	—	—
France	1921	75	348,018	1	4,617	98·7	1·3
	1920	97	395,264	2	260	99·3	·06
Holland	1921	109	300,419	14	13,460	95·7	4·3
	1920	159	429,914	11	19,485	95·3	4·3
Italy	1921	68	357,397	32	30,373	90·8	7·7
	1920	67	300,703	48	49,984	82·6	13·72
Japan	1921	35	144,912	—	—	100·0	—
	1920	59	248,513	—	—	100·0	—
Norway	1921	33	46,864	5	14,220	76·1	23·1
	1920	42	61,277	15	22,176	73·0	26·4
Portugal	1921	2	1,243	4	2,250	16·2	29·3
	1920	—	—	—	—	—	—
Spain	1921	15	69,787	—	—	99·8	—
	1920	26	89,190	—	—	99·7	—
Sweden	1921	8	15,411	16	60,347	19·7	77·1
	1920	36	63,470	22	57,328	51·7	46·8
Total building abroad*	1921	445	1,604,138	93	180,098	88·3	9·92
	1920	811	3,182,851	132	227,492	91·7	6·55
United Kingdom	1921	472	2,450,283	37	188,396	92·8	7·12
	1920	829	3,474,855	57	227,010	93·7	6·12
Total for the World	1921	917	4,054,421	130	368,494	91·0	8·27
	1920	1,640	6,657,706	189	454,502	92·7	6·34

* Excluding Germany.

type, this would give a slight advantage to the motor ship, but would, of course, tend to reduce the average tonnage of the motor ships building.

There have not been very many ships laid down during the last quarter. Of the 42 vessels of 91,094 tons commenced abroad during the last quarter, only one of 600 tons, building in Norway, is being equipped with an internal-combustion engine, and of the 17 vessels of 55,160 tons commenced in the United Kingdom during the same period, only one, of 130 tons, is being fitted with an internal-combustion engine. These figures, however, may be taken as abnormal. Since the turn of the year orders for three big ships have been announced. These relate to two liners for Alfred Holt & Co., one to be built by Cammell Laird & Co. Limited, at Birkenhead, and the other by Scott's Shipbuilding & Engineering Company Limited, at Greenock. The latter ship will be propelled by the Still engine, which is a combination of steam and the internal-combustion type. The Ellerman liner, to be built by Swan, Hunter & Wigham Richardson Limited, on the Tyne, will have quadruple expansion engines.

COMPRESSED AIR FOR MOTOR SHIPS.

IN Diesel-engined ships the economical and reliable production of compressed air is a matter of the utmost importance, for upon it depends the safety of the ship. So far, the only known method of starting the main engines is by the use of compressed air, and when navigating in or out of harbour, where frequent starting and reversing of the engines may be demanded, it is apparent that the amount of compressed air required may be very considerable. In addition, a large number of different designs of Diesel engines employ compressed air for the pulverisation of the fuel oil and its injection into the cylinder of the engine, and here again a reliable and steady supply of air is essential to the satisfactory operation of the engine.

A very interesting description of the various types of air compressors which are available for use on motor ships was given by Mr. William Reavell in the paper entitled "The Use of Compressed Air in Diesel-Engined Ships," which he read on January 27, before the North-East Coast Institution of Engineers and Shipbuilders. Mr. Reavell is a member of the firm of Reavell & Co. Limited, of Ipswich, who have become recognised as the manufacturers of high-grade air compressors of different types for merchant ships, and while his descriptions referred principally to the products of his own firm, they may be taken as representative of the best practice in this country. It is specified in Lloyd's Rules for motor ships that in addition to the main air compressor, auxiliary and emergency compressors must also be fitted. Where air blast fuel injection is employed, the main compressor is generally driven off the main engine, either by means of rocking levers driven from one of the main engine crossheads or by being direct coupled to the main crankshaft, usually at the front end of the engine. Both these types are illustrated and described in the paper. The chief difficulty regarding the design of the main compressor lies in the choice of a suitable capacity. If this is made sufficiently large to enable it to not only supply the injection air, but also to be largely responsible for the starting and manœuvring air, it follows that when the vessel is at sea the compressor will not be required to work at anything approaching full load since there will be little or no demand for starting air.

It is very clearly demonstrated in the paper that to run the compressor on light load is very uneconomical, leading to increased temperature at the various stages, particularly if throttle regulation is adopted. The author makes the valuable suggestion that the capacity of the main compressor should be reduced and that the replenishment of the starting air bottles be left to the auxiliary and the emergency compressors. The main compressor would then be of sufficient capacity for the injection of the fuel and would, therefore, work at its maximum capacity—the condition of maximum efficiency. This, it is claimed, would lead to a saving of first cost, weight, fore and aft length and power, despite the fact that the capacity of the auxiliary and emergency compressors might have to be somewhat greater than present practice demands. The design of the auxiliary compressor itself follows very clearly the design of the main compressor, except that it is independently driven.

COSTS OF ELECTRIC WELDING.

THE costs of any system of electric welding are primarily governed by wages and the price of the electrodes. The former need not be high, since boys are able to operate many of the types of present-day welding machines. In most machines there are tappings for the different gauge of electrodes and the various types of welds, while some makers issue very full instructions with their machines regarding the size of weld, current necessary, and the number of electrodes required for the thickness of plate, angle, &c., to be welded. Every machine incurs cost for upkeep, but the maintenance costs for electric welding plant are low in comparison with many other shipyard tools, and in addition, the first costs of machine and wiring are small. The first costs of alternating or direct current welding machines are about equal, although with alternating current welding machines it is unnecessary to have motor generator or transformer as with direct current plant.

It is sometimes claimed that "A.C." current welding has more penetration than "D.C." and a more uniform effect for the consumption of the same amount of electrical energy. This claim would be difficult to substantiate, for if the correct heat is obtained for the electrode and work, and a close arc is held to prevent oxidation, it is of little moment whether "D.C." or "A.C." be the current used. It is, no doubt, necessary in yards which use "A.C." current to install a motor generator if "D.C." current welding is to be adopted, and thus create extra expense for upkeep, but most yards require to have "D.C." current for temporary lighting of vessels when under construction in the yard, and further, any extra expense for running a generator is small in comparison with the cost of the electrodes, and as already stated, it is this item that principally governs electric welding costs.

As indicating the influence of the choice of electrodes on the costs of welding, the following table, showing the cost of electrodes per foot of weld taken on the same machine for four different makes of electrodes, is of interest :—

Thickness of plate.	No. 1. s. d.	No. 2. s. d.	No. 3. s. d.	No. 4. s. d.
$\frac{1}{4}$ in.	0 $6\frac{3}{8}$	0 1	0 $4\frac{3}{4}$	0 $6\frac{1}{2}$
$\frac{3}{8}$ "	0 $9\frac{3}{8}$	0 3	0 $8\frac{1}{2}$	0 10
$\frac{1}{2}$ "	1 $3\frac{1}{4}$	0 $5\frac{3}{4}$	1 $2\frac{1}{4}$	1 5
$\frac{5}{8}$ "	1 $5\frac{1}{2}$	0 11	1 $7\frac{1}{4}$	2 $7\frac{1}{2}$
$\frac{3}{4}$ "	2 6	1 2	—	3 9

When the consideration of all construction costs is so important as at present, and when cheaper production is urgent, electric welding for many items in ship construction will reduce both the cost and the weight of material required. Reduction in cost will be apparent whether "A.C." or "D.C." welders are used, provided the proper electrodes are employed and boys are trained to perform the duties. But the work intended to be electric welded should be specially designed for it and not necessarily be the same as for riveted work. Badly designed steel work, in many instances, requires the employment of numerous corner angles, which are not essential for electric welded work. The latter can be butted and flanged, and this saving in the weight over riveted work in which it would be necessary to overlap and fit angles should be taken into account when comparing costs of electric welding *versus* riveting.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Lexique Technique Anglais-Français. By G. Malgorn, with the collaboration of M. Desmarets. Paris: Gauthier-Villars et Cie., 55, Quai des Grande-Augustins, 55. 5 in. × 7⅝ in. × ⅝ in. 216 + xxi pages. Price 10 fr.

There are many technical dictionaries on the market, but there always seems to be an insistent demand for more. This one differs from the majority with which our readers are familiar, as it is of French origin, and is published in Paris. In addition to being a dictionary in English-French, there are numerous tables of weights, measures, and so on. The author has sought his words and definitions from a large number of English engineering periodicals and from machinery catalogues.

Metric System for Engineers. By Charles B. Clapham, Hons. B.Sc. Eng.(Lond.). London: Chapman & Hall Limited, 11, Henrietta Street, W.C. 2. 5⅝ in. × 8¾ in. × ¾ in. 181 + xii pages. Price 12s. 6d. net.

This volume is one of the D.U. Technical Series started some years ago. We have already had "Arithmetic for Engineers," by Mr. C. B. Clapham, and "Mathematics for Engineers," by Mr. W. N. Rose. In the new volume both the editors of the series and Mr. Clapham have kept up the standard which we believe was first set by the late Mr. Wilfrid J. Lineham. As in the case of the other two publications, all the examples and illustrations of the various mathematical principles have been worked out with a direct engineering interest. In the present volume Mr. Clapham does not seek to advocate the compulsory adoption of the metric system; he explains it from the point of view of the engineer, embodying, of course, a large volume of engineering data.

Regulations Relating to the Examination of Engineers in the Mercantile Marine. (Board of Trade.) London: His Majesty's Stationery Office, Imperial House, Kingsway, W.C.2, and usual agencies. 5½ in. × 8½ in. 63 pages. Price 9d. net.

This is a reprint of the 1916 edition with alterations and supersedes the regulations contained therein. The list of examination ports has been revised, and the qualifications for motor certificates, together with the syllabus of examination for both second-class and first-class certificates have been amended. The whole of the chapter on the conduct of examinations has been re-cast, and there is a new appendix giving a list of text-books recommended. There are various other alterations. While some of them are only of a verbal character, others are of a radical nature.

Ice and Cold Storage Trades' Directory. London: Iliffe & Sons Ltd., 20, Tudor Street, E.C. 4. 6¼ in. × 9 in. × ¾ in. 244 pages + xxv pages advertisements. Price 10s. 6d.

The seventeenth issue of this Directory for the various interests in connection with the cold storage, ice-making, and refrigerating industries has been carefully revised and brought up to date, including the addition of several hundred new names in the alphabetical and classified trades sections. The list of vessels fitted with refrigerating machinery, which forms such an important section of this Directory, has received very careful attention, owing to so many new vessels having been added to the various fleets, including the return of most of the vessels remaining under Government control at the time of the last issue, and the assigning of certain foreign vessels to British owners under the Reparation clauses of the Peace Treaty.

Bureau Veritas Répertoire Général. General List of Merchant Shipping. Vol. I. Steamers and motor vessels. 11½ in. × 11 in. × 3 in. 1,390 pages. Vol. II. Sailing vessels and auxiliary sailing vessels. Paris: 31, Rue d'Offémont. 11½ in. × 11 in. × 2 in. 828 pages.

The Register of the Bureau Veritas has been published annually since 1828, and gives alphabetically the names of all sailing, steam and motor vessels to which the construction or repairs have been superintended by the surveyors of the Society stationed at the principal ports of the world. The Répertoire Général, with which we are particularly concerned, has been issued annually since 1870. It is published in two volumes, one of which deals with steamers and motor ships, and the other with sailing vessels and sailing vessels fitted with auxiliary engines or motors. According to the general statistics published in the two volumes, the British tonnage owned is 20,140,115 gross tons; America comes next with 13,488,508; France comes next with 3,003,305; and Japan and Italy own each between two and three million tons. These figures relate to steam and motor vessels only. America takes first place as an owner of sailing ships with 1,138,578 gross tons; British tonnage is only 733,480; and the German is 393,853. Other countries with about 300,000 tons of sailing ship tonnage are France, Norway, Finland and Japan. The total tonnage of steamers owned throughout the world is given as 56,003,925 gross tons; motor ships total 1,031,067 tons; auxiliary vessels account for 394,406 tons, and sailing vessels 4,351,105.

TRADE PUBLICATIONS.

Lubricating Oil.—The Vacuum Oil Company, whose London address is Caxton House, Westminster, S.W., have issued an interesting illustrated booklet on their various brands of "Gargoyle" oils and greases, with a list of ports where these lubricants can be obtained.

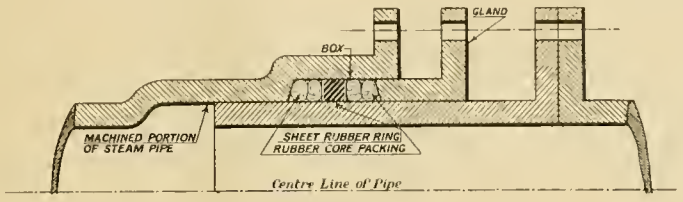
Burmeister & Wain.—To commemorate its transference into a limited company, 50 years ago, Burmeister & Wain, engineers and shipbuilders, Copenhagen, Denmark, have issued a handsome book giving the history of the firm, and particulars of its productions since 1872, special attention being paid to their Diesel engines. The volume is profusely illustrated, views being given of the management, the works, and of vessels either built or engined by the company, the whole forming a very interesting book and is worthy of bearing the name of this company of which much has been heard since the increase of motor ship construction.

William Beardmore & Co. Limited.—The latest catalogue issued by Wm. Beardmore & Co. Limited's publicity department, of 183, West George Street, Glasgow, is devoted to the Beardmore-Tosi Diesel engine, which was described in our pages last month. A general specification of this engine is given together with illustrations of the various parts and approximate overall dimensions of the four standard types of engine. In addition, information is given with regard to the number of auxiliaries nominally carried in a single or twin-screw ship, and interesting figures relating to the comparison of running costs of Diesel ships with steam ships of 1,000 b.h.p. and 2,400 b.h.p. The publication is very finely illustrated, and is sure to be very useful to all interested in the question of ship propulsion and Diesel engines.

MARINE ENGINEERING NOTES.

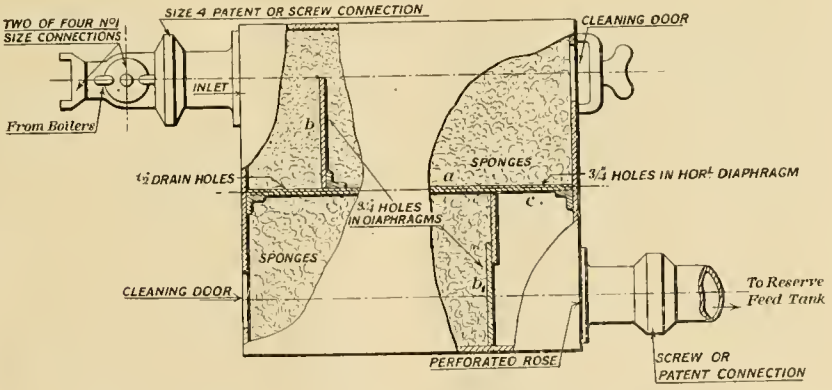
Steam Tightness of Expansion Glands—A Method of Economising Boiler Feed Water.

In turbine-engined ships using high-pressure steam (say 250 lb. per sq. in. at boilers), great difficulty is experienced in keeping the expansion glands steam tight. This is particularly the case with the glands on the main steam line to the turbines. To obviate this big matter of steam loss, the following method has been successfully adopted. We will take a gland which when fully packed takes five turns of packing as shown below. The first two are the ordinary rubber core. Next a rubber ring, cut from a sheet of ½-in. indiarubber, is inserted, and the two remaining rubber core turns fitted, the gland being then screwed up in the ordinary way. After six months' continuous steaming it was found that the gland metal showed no signs of wear.



Half Section of Gland.

When running down marine boilers, especially those of the small-tube water-tube type fitted with lower water drums, it has been the usual practice to allow the water when down as far as the lower drums to run to waste in the bilge. This is on account of the sediment, dirt, and impurities found in the water at this stage, which, if allowed to run into the reserve feed tanks, might possibly contaminate the clean feed water and also tend to dirty the surfaces of the tanks. To obviate this big loss of feed water, which, of course, for modern steam generators must be distilled, the fitting, a drawing of which is reproduced below, has been introduced. As will be seen, the construction is very simple, and the apparatus is easily made and fitted on board an ordinary steamer by the engine-room staff.



Sectional Elevation of Boiler Water Filter with Sponges.

The fitting consists of a cylindrical drum (an old paint drum makes an efficient shell), which should be about 18 in. in diameter by 18 in. long. The drum is fitted with a perforated horizontal centre diaphragm *a*, which divides the vessel in halves. This diaphragm is divided by perforated vertical baffles *b*, b_1. The object of the top baffle is to prevent the sponges being pushed to the back end, or the end furthest from the inlet, and the lower vertical baffle keeps the outlet orifice as clear as possible from the same effect. A free passage and complete percolation is thus ensured owing to the sponges being uniformly distributed over the case. A minimum number of holes are drilled in the horizontal diaphragm over the space *c*, the majority of the holes being in the centre of the diaphragm. As will be seen, the inlet fitting will take a No. 4 patent or screwed connection, which in turn is fitted with four No. 1 connections, two only of which are shown. To these No. 1 connections the running-down hoses of the boilers are attached. On the outlet side a No. 4 patent or screwed connection connects the hose with the reserve feed tanks. Cleaning doors are provided at front and back ends as shown, these being provided with the usual dog fasteners. It is usual to fit one filter in each boiler room, and between any pair of boilers. It should be fitted so that the top of the filter is just below the lowest part of the water drums or feed collectors, and must be very securely fastened to the framing.

In the filter shown (the diagram is not to scale) sponges are used as the filtering medium; but the shell could easily be fitted to use towelling or fine wire netting.

TYNE COMMISSIONERS AND DISPOSALS BOARD VESSELS.

At the January meeting of the River Tyne Commissioners it was stated that at the end of the year there were no fewer than 121 vessels laid up in the river, and of these 35 were owned by the Government under the charge of, it is understood, the Disposals Board of the Board of Trade Mercantile Marine Department. That department, in answer to yet another plea from the Commissioners to have some of the vessels removed, replied that the Disposals Board were doing their best to get rid of the vessels. The Commissioners have decided to take the step of asking their engineer to arrange to have the concrete tugs and lighters removed elsewhere in the river, and ask the Government to pay for the new moorings.

Members of the various sections of the welding industry, at an inaugural meeting held on January 26 at the Holborn Restaurant, adopted a proposal to form a new welding society embracing all systems of welding. A strong committee, with power to add to their number, representing the different interests, was elected to draft the constitution with a view to registration after same has been approved by a general meeting which will be called at an early date. The name agreed upon is the Institution of Welding Engineers, and all interested in the welding and allied industries will be eligible for membership. The offices (*pro tem.*) are at 30, Red Lion Square, London, W.C. 1. Mr. C. Raggett is Hon. Secretary *pro tem.*

THE QUALITY OF STEAM.

Moisture in Steam—Its Effect on the Operation and Efficiency of the Engine—The Measurement of the Percentage of Water in Steam.

In engineering practice the term "quality of steam" is generally employed to indicate the amount of moisture which is held in suspension by the steam at any point in its path from the boiler to the condenser. The term might, of course, be also used to indicate the amount of impurity which is carried along by the steam, only unfortunately the majority of engineers are under the impression that no matter how impure the water in the boiler may be, the steam which is produced from it always consists of water vapour that is chemically pure, *i.e.*, it is actually H_2O and nothing else. If we could be assured that the steam leaving the boiler did not contain any water particles, that is, if it were perfectly dry steam, this would be very nearly true, and subsequent condensation would not affect the purity of the wet steam; but it often

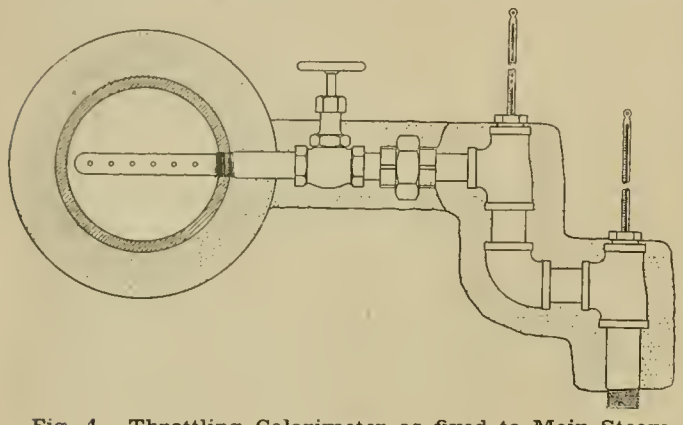


Fig. 1.—Throttling Calorimeter as fixed to Main Steam Pipe.

happens that some of the impurities in the feed water are of a volatile nature at high temperatures, and in the process of producing steam these volatile substances often find their way into the engine with the steam. When, however, the steam contains a certain proportion of water particles these water particles, which are thrown off from the surface of the water in the boiler, may be assumed to be of the same purity as the water from which they are produced, and hence, particularly in marine practice, where there is always a possibility of salt water finding its way into the feed from the condenser, the presence of moisture in the steam leads to the carrying over of particles of impurities which are ultimately deposited at all parts of the system.

It will be realised, therefore, that the measurement of the percentage of moisture in the steam yields an indication of the amount of impurity in the steam, and to this extent may be said to give an idea of the quality of the steam The effect of moisture in the steam is very serious owing to the presence of these particles of solid matter in it. Particularly when the boiler is "priming"—that is when a large quantity of water is being projected into the steam space—a considerable quantity of solid matter is being carried over into the engine which is deposited throughout the system, diminishing the transfer of heat into the superheaters, interfering with the perfect closing of the valves, causing excessive wear on the working surfaces of slide valves and cylinders, and generally leading to inefficient working of the engine. Further, the presence of moisture leads to a wetting of the various surfaces of the engine, which, in its turn, leads to further condensation, so that there is a more rapid formation of water in the engine than would otherwise be the case. The evil effects of accumulation of water in both reciprocating engines and steam turbines are too well known to need recapitulation, but despite the most efficient drainage system there are very many cases on record of breakdown which can be traced to the accumulation of water.

But in addition to the evil effects of moisture referred to above which may be said to be mechanical in their nature, there are also the thermodynamic effects which, while they are not so well understood, are recognised as having an important bearing on the efficiency of working of the engine, and hence on the fuel consumption. In non-superheater engines the presence of moisture leads to increased condensation in the cylinder or casing, and thence to increased steam consumption, while with superheater engines moisture in steam from the boiler leads to a far lower degree of superheat being obtained, since it becomes the first duty of the superheater to dry the steam, and consequently in the engine or turbine the lower degree of superheat means reduced efficiency of operation and the earlier appearance of moisture as the steam expands.

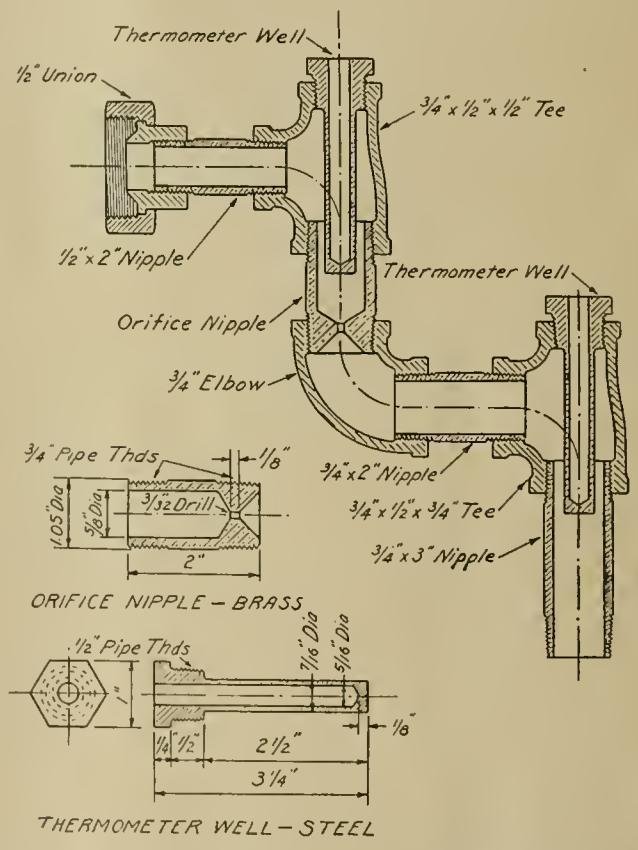


Fig. 2.—Details of Construction of Throttling Calorimeter.

The thermodynamical effects of moisture have been repeatedly demonstrated by engine and turbine tests, both with non-superheated steam and when superheated steam is employed.

It is rather remarkable, therefore, that despite the recognition of the evil effects of moisture in steam, both from the mechanical and the thermodynamical point of view, very few marine engineers ever take the trouble to investigate the quality of the steam generated by their boilers. The measurement of the percentage of moisture

in steam is generally regarded as being an experiment demanding the use of more or less complicated apparatus and involving certain difficult calculations, and hence it is seldom undertaken except during the evaporative trials of boilers in the shops. As a matter of actual fact it is quite a simple matter involving only the simplest apparatus to determine readily the quality of the steam in the engine room of a ship under actual working conditions, and it must be admitted that such knowledge would go a long way towards enabling the engineers on watch to obtain drier steam, thus ensuring more economical working with consequent saving of fuel and a greater freedom from breakdown and unnecessary repairs due to leaky valves, pistons, &c.

While there are other methods of determining the percentage of moisture in steam, the most simple is that which is based on the use of what is termed the "Throttling Calorimeter,"

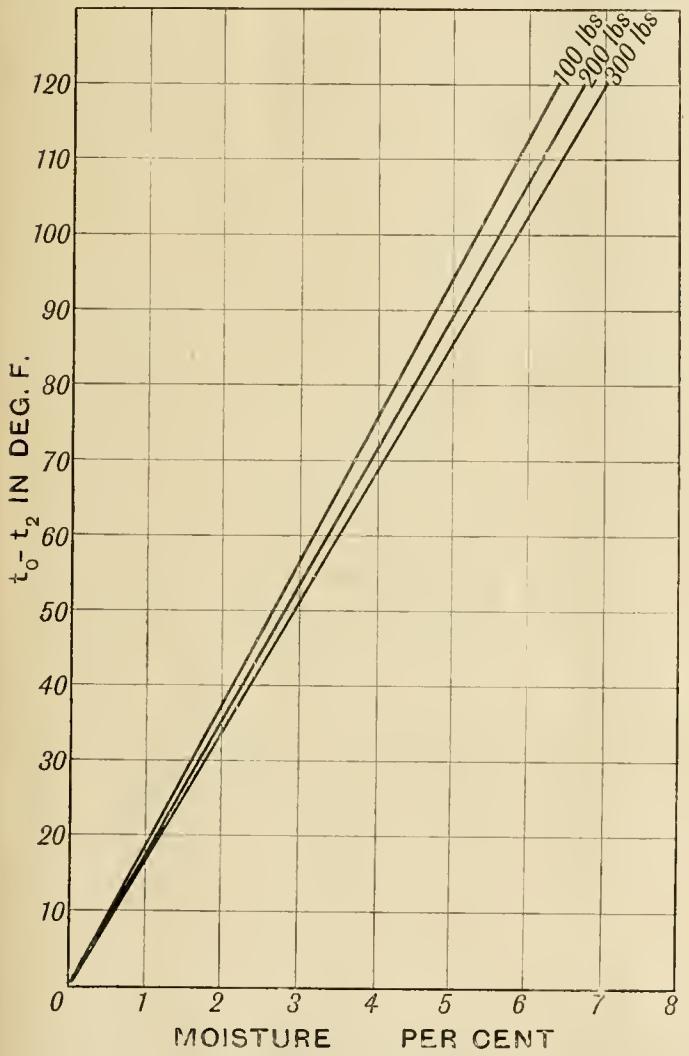


Fig. 3.—Chart giving Percentage of Moisture in Steam for use with Throttling Calorimeter.

the general arrangement of which as installed in the main steam pipe of an engine is shown in Fig. 1. It will be seen that the apparatus consists essentially of a sampling pipe, the length of which is approximately equal to the diameter of the steam pipe. This sampling pipe is provided with a series of holes, and the quality of the steam passing to the calorimeter may be considered as being the same as that passing to the engine. The supply of steam to the calorimeter is controlled by a screw-down stop valve as shown, beyond which there is a pocket containing a thermometer tube in which is placed an accurate thermometer, so that the exact temperature of the steam passing to the engine can be determined. Beyond this first thermometer pocket there is an orifice nipple through which the steam expands down to atmospheric pressure, while beyond this orifice and before the expanded steam escapes there is a second thermometer tube enabling the temperature of the steam after expansion to be accurately determined. The whole apparatus is very carefully lagged to prevent the loss of heat due to radiation and conduction. A sectional view of the calorimeter is shown in Fig. 2.

If we assume that there is no loss of heat as the steam passes from one side of the orifice to the other, it follows that the total heat contained in each pound of steam is the same before and after expansion, and since the total heat of saturated steam falls with a fall in pressure, the effect of expanding the steam is to cause superheating above saturation temperature at the lower pressure, provided, of course, that the steam did not originally contain too great a percentage of moisture. If the steam is very wet the effect of expansion may be merely to thoroughly dry it. Hence if t_1 °Fahr. is the temperature indicated on the first thermometer and t_2 °Fahr. the temperature on the second

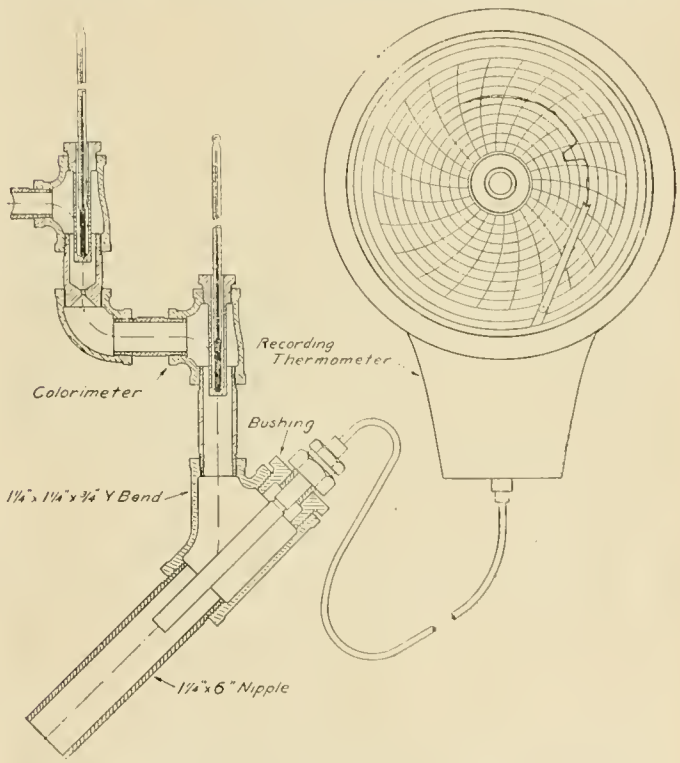


Fig. 4.—Recording Throttling Calorimeter, showing Variation of Moisture throughout the day.

thermometer, t_1 is the saturation temperature at the pressure in the steam main and t_2 is the temperature to which the steam is superheated at atmospheric pressure as the result of throttling.

If now H_1 = total heat per lb. of steam at saturation temperature, t_1 °Fahr. as obtained from the steam tables,

H_2 = total heat per pound at atmospheric pressure ;

L_1 = latent heat of steam at temperature t_1 ;

and x = wetness per lb. of steam.

The amount of heat carried by each pound passing through the calorimeter before throttling

$$= H_1 - xL_1,$$

since x pound has not received its latent heat.

The amount of heat carried by each pound after throttling

$$= H_2 + Cp\ (t_2 - 212),$$

Cp being the specific heat of steam at constant pressure measured at atmospheric pressure and 212° Fahr. being the saturation temperature at that pressure.

Hence by the principle of the conservation of energy, no heat being lost,

$$H_1 - xL_1 = H_2 + Cp\,(t_2 - 212)$$

$$\text{or} \qquad x = \frac{H_1 - H_2 - Cp\,(t_2 - 212)}{L_1}.$$

The value of Cp is generally taken as being 0·48 B.Th.U. per lb. per °Fahr. at atmospheric pressure, although a more correct value given in Prof. Callendar's steam tables is 0·49. Further, we can take H_2, the total heat at atmospheric pressure (14·7 lb. per sq. in.), as being 1150 B.Th.U. per lb., whence

$$x = \frac{H_1 - 1150 - 0{\cdot}49\,(t_2 - 212)}{L_1} \quad \ldots \quad \ldots \quad \text{(i)}$$

H_1 and L_1 are obtained from steam tables, but it is unnecessary to measure t_1 since these values can also be obtained if the pressure in the steam main at the sampling pipe is measured. One other factor should be taken into account, particularly at sea where the fluctuations of the barometer are between wider limits, and that is the atmospheric pressure at the time of the experiment. If this differs very materially from 14·7 lb. per sq. in. a correction for H_2 and 212° Fahr. should be introduced.

The "Radiation Loss."

The foregoing method of determining the percentage moisture in steam passing along a pipe line is very simple both as regards the measurements which have to be taken and the subsequent calculation, and it is frequently employed in practice. There is, however, a not inconsiderable error due to the fact that the velocity of the steam on the low-pressure side of the orifice is very much greater than that at the high-pressure side, and hence a certain proportion of the energy of the steam is converted into kinetic energy and is not available as heat energy for superheating the steam. In other words, the actual reading t_2 is lower than it should be. In addition, despite the most careful lagging of the apparatus there must always be a certain loss of heat due to co-induction and radiation. It is, however, possible to make an allowance for these two losses and thereby to obtain a more accurate value of x.

Let the combined effect of the loss due to the above two causes be denoted by R, the "radiation loss" as it is termed. Then by the principle of the conservation of energy we have :—

$$H_1 - xL_1 = H_2 + Cp\,(t_2 - 212) + R$$

$$\text{or} \qquad x = \frac{H_1 - H_2 - Cp\,(t_2 - 212)}{L_1} - \frac{R}{L_1} \quad \ldots \quad \ldots \text{(ii)}$$

The value of R cannot be directly determined, but it can be eliminated in the following manner. Suppose that the steam in the main pipe is perfectly dry, then the value of x as calculated by (ii) must be $= o$. If x_1 is the calculated proportion of moisture from observations during a test and x_o is the calculated value when the steam is initially perfectly dry, then x_o, which may be either positive or negative, will represent the error due to the use of the formula, and $x_1 - x_o = x$, the true value of the proportion of moisture in the steam. Hence, if t_o is the reading on the second thermometer due to the expansion through the orifice of dry saturated steam originally at a temperature t_1, we have :—

$$x_1 = \frac{H_1 - H_2 - Cp\,(t_2 - 212)}{L_1} - \frac{R}{L_1}$$

$$\text{and } x_o = \frac{H_1 - H_2 - Cp\,(t_o - 212)}{L_1} - \frac{R}{L_1}$$

$$\text{but } x = x_1 - x_o = \frac{H_1 - H_2 - Cp\,(t_2 - 212)}{L_1} - \frac{R}{L_1} - \left[\frac{H_1 - H_2 - Cp\,(t_o - 212)}{L_1} - \frac{R}{L_1}\right]$$

and simplifying and putting $Cp = 0{\cdot}49$ we have :—

$$x = \frac{0{\cdot}49\,(t_o - t_2)}{L_1}$$

or expressing the amount of moisture as a percentage, we have :—

$$x = \frac{0{\cdot}49\,(t_o - t_2)}{L_1} \times 100 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \text{(iii)}$$

This formula is considerably simpler than (i), and having determined t_o it only involves the determination of L_1, the latent heat of steam at the temperature t_1 (or at the pressure in the main steam pipe), which can be determined from the steam tables. The values of t_o are sometimes determined experimentally with the original throttling calorimeter, which is fitted with a sampling pipe having an opening at the end only, and mounted vertically in the steam pipe so that it takes steam from the top of the pipe where it may be assumed to be dry. On expanding this steam through the orifice the correct values of t_o can be read off on the second thermometer. It is, however, unlikely that the steam will be perfectly dry, particularly at sea, and hence the makers usually supply a table giving the values of t_o corresponding to different values of t_1, the saturation temperature in the steam pipe. A short table giving these values is appended, and intermediate values can be obtained by interpolation.

Table Giving Values of t_o for Different Steam Pressures.

Temperature of Dry Steam in Pipe Line t_1 °F.	Absolute Pressure in lbs. per square inch.	Gauge Pressure in lbs. per square inch.	Temperature after Expansion through orifice (Steam originally Dry), t_o °F.
331	105	90	290
338	115	100	294
344	125	110	297
350	135	120	300
356	145	130	302
361	155	140	305
366	165	150	307
371	175	160	309
375	185	170	311
380	195	180	313
384	205	190	314
388	215	200	316
392	225	210	317
396	235	220	319
399	245	230	320
403	255	240	321
406	265	250	322
410	275	260	324
413	285	270	325
416	295	280	326
419	305	290	327
422	315	300	328

With the above table, the determination of the amount of moisture merely involves reading from the calorimeter the values of t_1 and t_2, finding L_1 corresponding to t_1 from the steam tables, finding t_o corresponding to t_1 from the above table, and substituting in formula (iii).

It will be noticed that the value of t_o does not differ to any great extent with the pressure, and this has enabled the values of $t_o - t_2$ to be plotted on a chart from whence the percentage of moisture can be directly read off without employing the formula. This chart is shown in Fig. 3. Having obtained the value of $t_o - t_2$, the horizontal line corresponding to this value is followed until the diagonal pressure line is obtained either as given on the chart or by interpolation, which can be done by trial. Then, the vertical through the point of intersection gives the percentage of moisture on the horizontal scale at the foot of the chart.

In order to obtain a complete record of the behaviour of the boilers on board ship extending, say, over a complete day, it is obvious that observations of the temperature at the two thermometers would be required throughout the 24 hours. Such an experiment would be of the utmost value in checking the capabilities of the various watches in the stokehold, and it would enable the chief engineer to gauge with considerable exactness the time occupied at the commencement of each watch in cleaning fires. It would also serve to show at what periods foaming occurred in the boiler or whether the water was gradually becoming too dense, all of which would cause excessive moisture in the steam. It is, however, unnecessary to calculate the exact percentage of moisture in the steam for this purpose as a comparative measurement of the moisture throughout the test would serve practically the same purpose. In order to obtain a graphical record of the comparative amount of moisture in the steam, the throttling calorimeter is sometimes fitted on the low-pressure side with a recording thermometer as shown in Fig. 4. If now the pressure is assumed to remain constant throughout the entire period then the value of t_0 is also constant, so that the amount of moisture depends only upon the value of t_2. The values obtained on the recording thermometer can, if desired, be worked out periodically, which gives a very good idea of the behaviour of the boiler plant over a given period; but even without such calculation an accurate idea is obtained of the quality of the steam, and as will be seen from the record in Fig. 4, the short period of excessive moisture during the cleaning of the fires is clearly shown.

With marine boilers the above type of recording thermometer cannot be relied upon to give good results because of the assumption that the pressure remains constant is far from accurate. During the period of cleaning fires at the commencement of each watch the pressure falls considerably, and it may be half-an-hour or more before the normal pressure is again reached. Further, it is greatly to be preferred that an exact record of the actual percentage of moisture should be obtained, and hence to eliminate the disadvantage of the recording thermometer type of calorimeter and at the same time to enable the exact percentage of moisture at any instant to be obtained without any calculation whatever, direct reading instruments have been devised. The general arrangement of one of these direct-reading throttling calorimeters is shown in Fig. 5. This piece of apparatus which has been introduced by Power Specialty Company Limited, of 315, Oxford Street, London, W. 1, works on exactly the same principle as the type of calorimeter already described, except that only one thermometer is employed in order to give the temperature of the steam after expansion down to atmospheric pressure, a pressure gauge serving to indicate the condition of the steam before expansion. As will be seen from a study of Fig. 5, the steam expands through a needle valve into a copper vessel, the bottom of which is open to the atmosphere. In order to ensure that the pressure in the vessel does not rise above the atmospheric, a small glass U-tube containing mercury is fitted, at the back of which is a scale so that the observer can see at

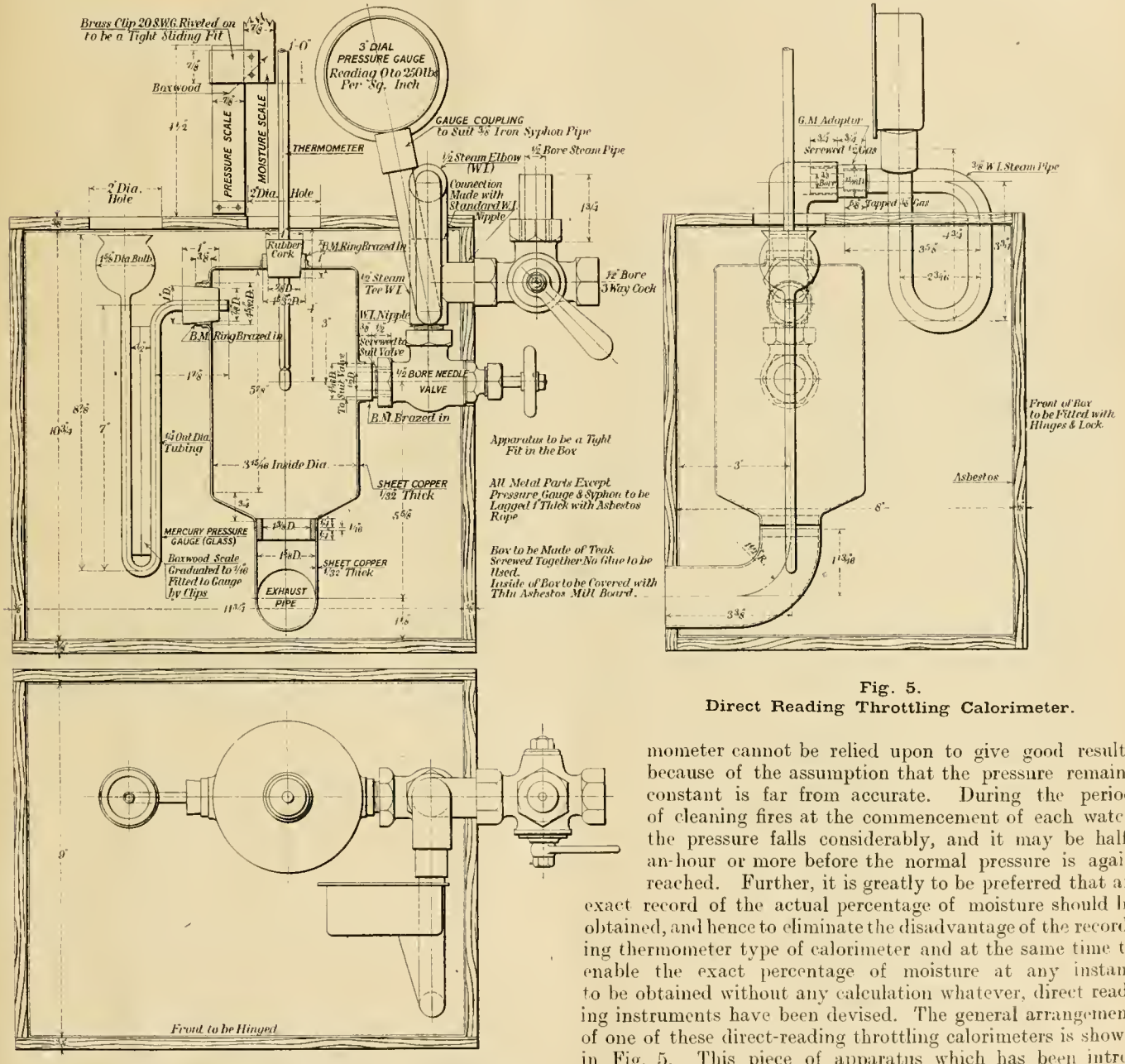
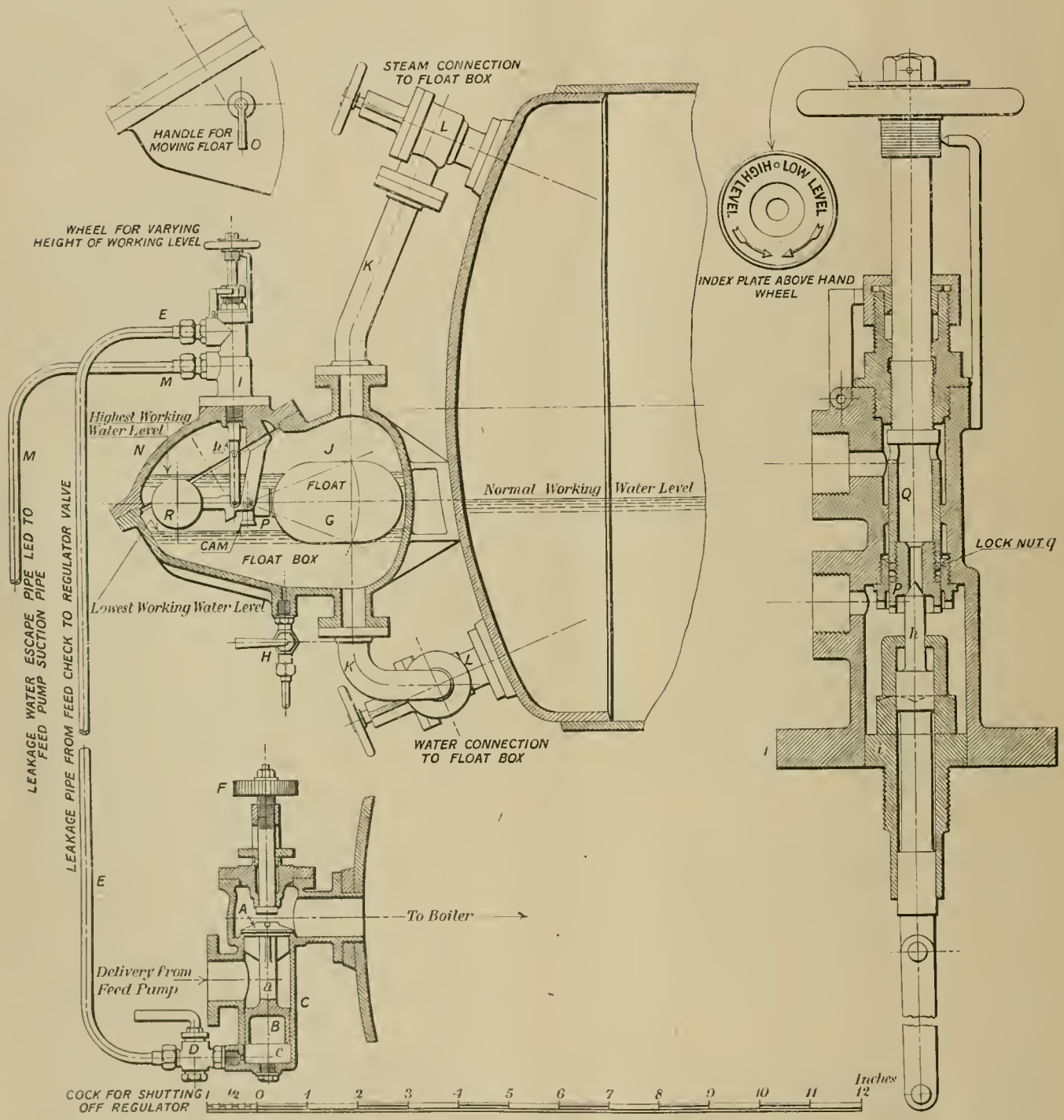

Brass Clip 20 S.W.G. Riveted on to be a Tight Sliding Fit
3" DIAL PRESSURE GAUGE Reading 0 to 250 lbs Per Sq. Inch
Boxwood
PRESSURE SCALE
MOISTURE SCALE
THERMOMETER
GAUGE COUPLING to Suit ⅜ Iron Syphon Pipe
½ Steam Elbow (W.I.)
½ Bore Steam Pipe
Connection Made with Standard W.I. Nipple
2" Dia. Hole
Rubber Cork
B.M. Ring Brazed In
½" Steam Tee W.I.
½" Bore 3 Way Cock
W.I. Nipple
Screwed to Salt Valve
½ BORE NEEDLE VALVE
B.M. Brazed in
¼ Out Dia. Tubing
3 15/16 Inside Dia.
SHEET COPPER 1/32 Thick
MERCURY PRESSURE GAUGE (GLASS)
Boxwood Scale Graduated to 1/10 Fitted to Gauge by Clips
EXHAUST PIPE
Front to be Hinged
Apparatus to be a Tight Fit in the Box
All Metal Parts Except Pressure Gauge & Syphon to be Lagged 1" Thick with Asbestos Rope
Box to be Made of Teak Screwed Together No Glue to be Used. Inside of Box to be Covered with Thin Asbestos Mill Board.
G.M. Adaptor
Screwed ½" Gas
⅜" W.I. Steam Pipe
⅜" Tapped ⅛" Gas
Front of Box to be Fitted with Hinges & Lock
Asbestos

Fig. 5.
Direct Reading Throttling Calorimeter.

a glance whether the height of the mercury is the same in each limb. The thermometer, which is fixed at the centre of the calorimeter, then gives the value of t_2. As before, the percentage of moisture is given by the formula

moisture scale, and on it are marked values corresponding to different percentages of moisture. To obtain a direct reading, when the apparatus has been thoroughly warmed up and a steady temperature is recorded on the thermometer, the


HANDLE FOR MOVING FLOAT
STEAM CONNECTION TO FLOAT BOX
WHEEL FOR VARYING HEIGHT OF WORKING LEVEL
HIGH LEVEL
LOW LEVEL
INDEX PLATE ABOVE HAND WHEEL
Highest Working Water Level
Normal Working Water Level
Lowest Working Water Level
FLOAT
CAM
FLOAT BOX
LOCK NUT q
WATER CONNECTION TO FLOAT BOX
LEAKAGE WATER ESCAPE PIPE LED TO FEED PUMP SUCTION PIPE
LEAKAGE PIPE FROM FEED CHECK TO REGULATOR VALVE
To Boiler
Delivery From Feed Pump
COCK FOR SHUTTING OFF REGULATOR
Inches

Mumford Automatic Feed Regulator being fitted on the White Star Liner "Majestic." (*See opposite page.*)

$$x = \frac{0{\cdot}49\,(t_a - t_2)}{L_1} \times 100.$$

Thus the amount of moisture depends upon the difference between a factor of the pressure and the thermometer reading. A scale of pressures is therefore mounted on the top of the box containing the calorimeter, and between this and the thermometer another scale is inserted which can be moved up and down on the pressure scale. This scale is called the moving scale is set to the position on the pressure scale corresponding with the boiler pressure. The height of the mercury column of the thermometer, as read on the moisture scale, then gives directly the percentage of moisture in the steam.

It is interesting to note that on one or two liners, records of the moisture of steam have been taken throughout a voyage across the Atlantic, and as a result it has been possible to effect considerable improvements in the operation of the boiler plant.

AUTOMATIC FEED REGULATION.

Mumford Automatic Feed Regulator now being fitted on the White Star Liner "Majestic"—the Biggest Ship in the World.

It has long been the practice on land and in the Navy, where water-tube boilers are almost exclusively employed, to install automatic feed-water regulators. Particularly with water-tube boilers, the task of maintaining a uniform level of water in the gauge glasses, despite fluctuations of speed of the main engines and variation of speed of the feed pumps due to changes in the steam pressure, is one of considerable difficulty, and various forms of regulator have been devised by means of which a fairly uniform level of water is maintained in the boiler despite the variation in the demand for steam. There is, of course, no reason why some form of feed regulator should not be fitted to the ordinary marine type of fire-tube boiler, except that owing to the large steam space available in these boilers the task of maintaining a constant level of water is seldom difficult, and consequently the majority of engineer-superintendents have not yet become convinced that the fitting of these regulators would make for more efficient operation. But with the gradual introduction of the water-tube boiler into the merchant service the need for automatic feed regulators will become imperative.

Feed Regulators on Merchant Ships.

It is of interest to note that at the present time the water-tube boilers of the White Star liner *Majestic* (the ex-German liner *Bismarck*), now lying at Hamburg fitting out for her maiden voyage across the Atlantic in the spring, are being fitted with automatic feed regulators. The boilers are of the Yarrow pattern, and the type of feed regulator being installed is that which is made by A. G. Mumford Limited, at the Culver Street Engineering Works, Colchester. A sectional drawing showing the details of this regulator is reproduced opposite, from which the action can easily be understood. It will be seen that the regulator consists essentially of a float chamber bolted on to the steam drum and connected to the drum by means of two pipes, one connecting the upper part to the steam space, and the other the lower part to the water space. Each of these pipes is provided with a screw-down stop valve, so that the regulator can be isolated from the boiler if necessary, enabling adjustments or repairs to be carried out without interfering with the operation of the boiler. Further, the float chamber is connected to a special form of feed check valve as shown, the check being secured to one of the lower water pockets as is usual on water-tube boilers. It should be noted that no other feed check valve is required.

The Mumford Automatic Regulator.

The special boiler feed check valve consists of an upper portion A, which is similar to the standard pattern screw-down non-return check valve as ordinarily fitted, but having in addition a spindle *a* terminating in a piston or plunger B, which works in the cylinder C, forming part of the casing of the check valve. This piston is made an easy working fit in the cylinder so that a small quantity of water can leak past it under pressure. The delivery from the feed pump enters the boiler through the check valve in the usual way between the valve A and the piston B. The area of the piston B is made equal to the area of the underside of the valve A, and as the feed water enters between A and B, the pressure acts equally in both directions and so keeps the valve shut. Meanwhile, however, a small quantity of water is being forced past the piston B into the clearance space *c*, and if this water were not able to escape by means of the small leakage pipe E, the pressure on the underside of B would balance that on the top side, and the valve A would lift, and feed water would enter the boiler. Thus if the cock D were closed, the regulator is cut out and the check valve functions in the ordinary way, while the opening of the cock D enables the water under the piston to escape, and the valve shuts down.

If now the opening or closing of the leakage pipe E is performed automatically by the rising or falling of the water in the boiler, it is evident that the check valve becomes self-adjusting. This automatic opening and closing of the leakage pipe is accomplished by means of a float G, contained in a float chamber J, which rises and falls with the water in the boiler, the float operating a small valve *h*, contained in a valve box I, to which the leakage pipe E is attached. As the level of the water in the boiler falls, the float descends and closes the valve *h*, thus stopping the flow of leakage water from under the feed check piston. Hence the check valve lifts and water is forced into the boiler by the feed pump. As the level of the water in the boiler rises, the float also rises, opening the valve *h* which permits the leakage water to escape, thus shutting the feed check and stopping the feed. The leakage water, after it has passed the valve attached to *h*, is led by the pipe M back to the feed suction pipe. It should be mentioned that the valve *h* works through a sleeve in the cover of the float chamber without the intervention of a stuffing-box, so that it is as nearly as possible frictionless. Further, by removing the cover N, the two valves L, and the cock D, being first of all shut, all the working parts can at once be removed.

Testing the Working of Regulator.

A handle O on the outside of the float chamber is provided for moving the float up or down to test its working. This handle is fixed to a spindle passing through a stuffing-box, and to the inside end of this spindle is attached a cam P. When the handle is moved some distance to the right or left, the cam comes into contact with the underside of the float lever and pushes the float up or down as desired, but when the handle is placed in its central position, which is vertical as shown, the float lever has its full range of motion without coming into contact with the cam.

As it is sometimes considered necessary to vary the working level of the water in the boiler, means are provided for enabling this to be done. The seat of the regulating valve *h* is attached to a hollow spindle carried up through the casing I, and fitted with a screw and hand-wheel, by means of which it can be raised or lowered. The details of this valve are shown to the right of the drawing of the regulator. This alters the point at which the float opens or closes the valve, and thus enables the working level of the water to be varied to a certain extent. The seat is then locked into position by means of a lock nut.

It has been demonstrated in actual practice that these automatic regulators are capable of regulating the level of the water in the steam drums of water-tube boilers even under the severe conditions of naval practice. It is on record that in a certain boiler one of the tubes burst, but despite the leakage of water the regulator still functioned and a constant level was maintained. It would appear, therefore, as though their application to fire-tube boilers would prove advantageous.

This system of automatic feed-water regulators has been fitted to the majority of the vessels in the British and Foreign Navies (including the *Hood*). Merchant vessels recently equipped include the Cunard liner *Berengaria*, the Canadian Pacific *Empress of China* (recently known as the *Tirpitz*), and the *Cap Polonio*, which has been repurchased by the Germans.

SPEED-REDUCTION GEARING.

Some Points of Interest in the Manufacture of Marine Speed-Reduction Gearing as practised by the Power Plant Company Limited, West Drayton.

The most striking feature in the history of marine engineering during the past decade has been the rapid rise to favour of the geared turbine. The steam turbine was early in its evolution recognised as being particularly suitable for the propulsion of ships, not alone on account of its reliability and economy, but because of the reduction of weight as compared with the reciprocating steam engine of the same power, the smaller space it occupied and the freedom from vibration when it was running. But these advantages were to a very large extent discounted by the higher speed of rotation, and, as a result, it was deemed impracticable to employ the direct-coupled turbine save for the propulsion of high-speed vessels. It was in 1910 that Sir Charles Parsons fitted the *Vespasian* with mechanical speed-reduction gearing, whereby the speed of the turbine could be kept high while still employing an economical propeller speed. These gears, which had double helical teeth, were the first gears to be fitted on a merchant vessel, and from the outset they proved an entire success, until to-day, instead of the 1,100-h.p. transmitted by the gears of the *Vespasian*, we have, as on H.M.S. *Hood*, no less than 140,000-h.p. transmitted through gearing to four propeller shafts, representing 35,000-h.p. per gear. Moreover, while the original gears gave a single reduction of speed between the turbine and the propeller, with a view to employing turbines running at the highest speeds, double-reduction gears have been introduced in which the turbine speed is reduced in two stages giving in many cases a ratio of 60 to 1.

Gear-Cutting Systems.

But while the single-reduction gearing could claim to have been an unqualified success, in the initial stages of the development of double-reduction gears, certain troubles were experienced, excessive wear of the teeth being found to have taken place very early in the life of the gear. This was particularly the case with several of the gears installed in the American vessels which were built with such rapidity during the later stages of the war. Several theories were advanced to explain the probable cause of these various failures, but it has now been recognised that in the majority of instances the failure was due either to faulty workmanship in regard to cutting and alignment or to the use of defective material. The idea that too high a tooth pressure was being employed was effectively disproved by Mr. R. J. Walker and Mr. S. S. Cook in the paper entitled "Mechanical Gears of Double Reduction for Merchant Ships," which they jointly presented last year at the Spring Meetings of the Institution of Naval Architects, and the reader is referred to that paper for a notable contribution on the subject. There has existed, therefore, among marine engineers a certain amount of distrust for the double-reduction gearing, and it is only now that this feeling is being dispelled by the recognition of the fact that, with careful designing and accurate production, these gears are just as reliable as the single-reduction gear.

In order to ensure accurate production of the gears, various systems of cutting the gear teeth have been devised, since it is realised that the crux of the problem lies in the formation of the wheel teeth. Owing to the large powers which have be transmitted and the high peripheral speed at which the gears are run, any slight inaccuracy of the teeth either on the pinion or the wheel or any error of alignment tends to concentrate the pressure on one or two points instead of it being distributed for the entire width of the tooth face, with the result that rapid wear occurs at those points. Wear at any one point is quickly followed by wear at other points, since the entire gearing is thrown out of truth, and ultimately failure occurs. In the earlier examples of double-reduction gearing, the teeth were cut on the hobbing machine in the same way as the single-reduction gears had for many years been successfully cut. But the hobbing machine, while it yields a highly economical method of cutting double helical teeth, leaves something to be desired on the score of accuracy, particularly as the hobs become worn or when the machine itself is showing signs of wear, and on this account other and more accurate systems of gear cutting have been devised.

Sykes System.

Notable among these is the "Sykes Gear Generating System," in which two cutters, in the form of helical pinions, one right hand and the other left hand, reciprocate across the face of the wheel, at the same time having a twisting motion imparted to them which makes them, in effect, equal to a double helical pinion. At the same time a slow revolving motion is imparted to the cutters and also to the wheel being cut, thus giving the same motion as a wheel and pinion in gear together. The ends of the cutter teeth are sharpened so as to form cutting faces and the process represents a simple generating moulding system. The cutting action is continuous, one cutter being arranged to make a return stroke while the other is on a cutting stroke. The generating revolving motion, which is very slow, is also continuous, thus eliminating all trouble due to backlash and intermittent indexing of the teeth. It is claimed that the slow motion and the very light stresses to which the indexing mechanism is subject prevent any appreciable wear, with the result that the machine maintains its accuracy over a very long period.

The right and left-hand portions of the teeth produced by the Sykes machines meet perfectly at the centre of the wheel face so that the length of the teeth is the entire width of the wheels, no gap in the centre of the face being necessary; consequently a larger effective width of teeth is available over any given width of face. In the machines designed in accordance with the Sykes patents the cutters are arranged to move towards the wheel blank so that they can be fed to the correct depth by means of a micrometer screw. Very accurate finishing cuts can thus be taken and the teeth in wheels can be very accurately duplicated. It may be noted that the form of teeth on the cutters is purely involute and that they are designed and generated by a grinding process in such a way that however much the cutting edges are ground back in sharpening the teeth the profiles are purely involute to the same base circle. This ensures that the cutters generate exactly the same form of tooth throughout their entire life. The Sykes machines have been in use for several years and have produced a large number of marine turbine gears, many of which have been in constant service with satisfactory results.

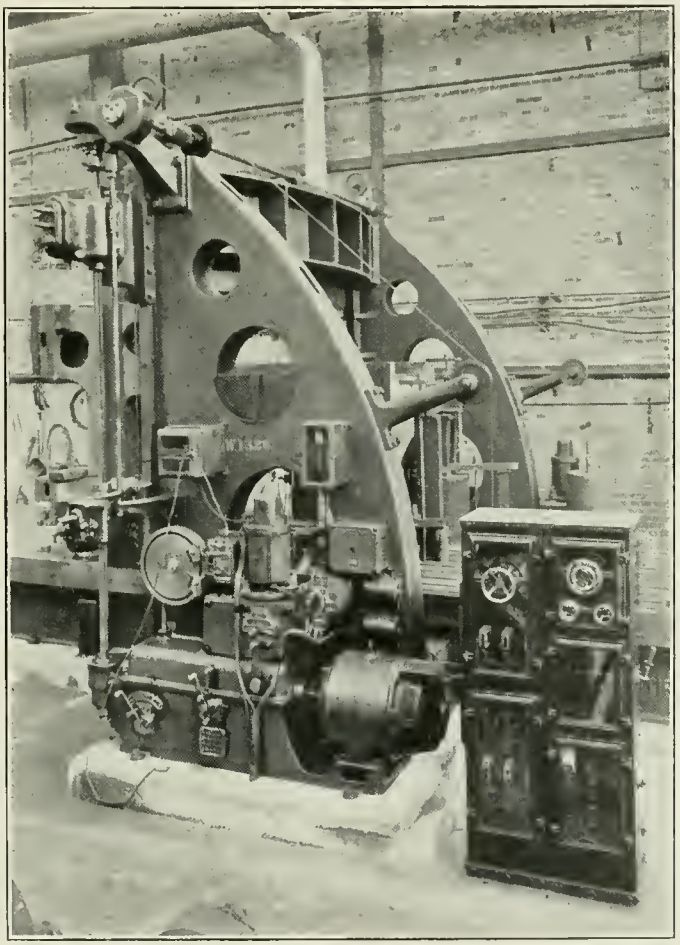
Sunderland Process.

Another system of gear cutting which, it is claimed, gives very accurate results, is that known as the "Sunderland Process" in which straight-sided cutters are employed. The system is based upon the fact that with involute teeth, such as are invariably employed on gears for marine purposes, the form of the tooth on a rack is composed entirely of straight lines. Such a rack will, of course, mesh accurately with gear wheels of any diameter having involute teeth of the same pitch, and the Sunderland process is based upon this fact. The wheel teeth are generated by a cutter which takes the form of a rack, the motion of the cutter and the wheel blank being such that an accurately-shaped tooth is gradually formed as the wheel rolls along the rack, the cutting motion of the rack being

similar to that in a slotting machine. When in its rolling motion the wheel has reached the end of the rack, the rack is moved back to the original starting position. The wheel, of course, is not subjected to a corresponding motion, so that cutting proceeds continuously around the periphery of the wheel.

With a view to showing different practices, several firms have kindly placed facilities at our disposal for photographing work on their machines, and in the present issue we propose to deal with the works of the Power Plant Company Limited, West Drayton. These works are equipped to deal with gears of all types and sizes, and further, in order to ensure the accuracy of the gear-cutting machines which they employ, the company also manufacture gear-cutting machinery both for their own use and for sale.

The main machine and erecting shop, an illustration of which is shown on page 57, is 500 ft. long by 70 ft. wide, and in it are to be found, in addition to the usual type of lathes, planing machines, radial drilling machines, &c., several gear-cutting machines of exceptional interest. The marine gears and others where high speeds are employed are cut on machines of the Sykes' gear generating pattern, of which there are no fewer than nine machines at present installed, all of which have been constructed by the Power Plant Company. Of these, four are capable of taking pinions up to 24 in. diam., four of a larger size can deal with wheels up to 48 in. diam., while the largest machine will take a wheel up to 16 ft. diam., having a width of face of 54 in. It may be mentioned that another and a larger machine is at present under construction in the shops which will be capable of taking wheels up to 18 ft. diam.



Electric Control Gear of Stirk Universal Planer, in use by the Power Plant Company Limited.

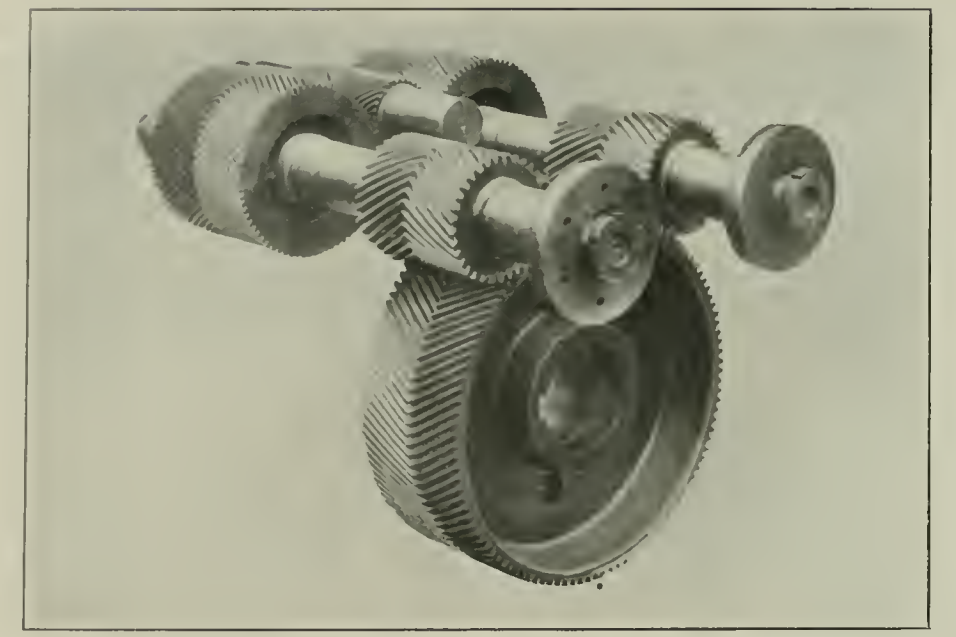
Another very interesting machine is the Stirk Universal Planer, which is employed for machining the casing of the gears. This machine, which is illustrated on page 59, has a stroke of 25 ft., the maximum width of the bed being 10 ft. In addition to planing either a horizontal or a vertical surface, it is equipped with an arrangement whereby it can operate as a slotter for machining internal surfaces. The machine is driven by a reversible motor of 50 b.h.p. operating at 375 volts d.c., the motor having been supplied by the Lancashire Dynamo & Motor Company. The gear for controlling the backward and forward motion of the machine is electrically operated, so that it is a very simple matter to vary the length and position of the stroke. This control gear, together with the switchgear for reversing the main driving motor and the motor which operates the feeds, is shown in the illustration above. When the machine is running, the entire control is operated by means of a push button at the end of a flexible lead which can be carried by the operator as he stands on the table of the machine. This control button is seen on the foundation of the machine in the illustration. For machining the surfaces of the wheels prior to cutting the teeth, there is a large vertical boring machine, shown on page 58, capable of dealing with wheels up to 15 ft. diam. This machine is capable of turning the outside surface and boring the nave of the wheel simultaneously. It is also employed for boring the steel rims of the large gear wheels which are afterwards shrunk on to the cast-iron centres. For this work extreme accuracy is required.

While the more accurate work of forming the teeth for the wheels and the pinions is carried out on the newer Sykes' gear generating machines, there are a number of the older hobbing machines still in service which are now employed in cutting gears for winding engines, &c., where the peripheral speeds are not nearly so high as in marine work. One of these machines is illustrated on page 58. Another interesting hobbing machine is that which is employed for cutting worm wheels.

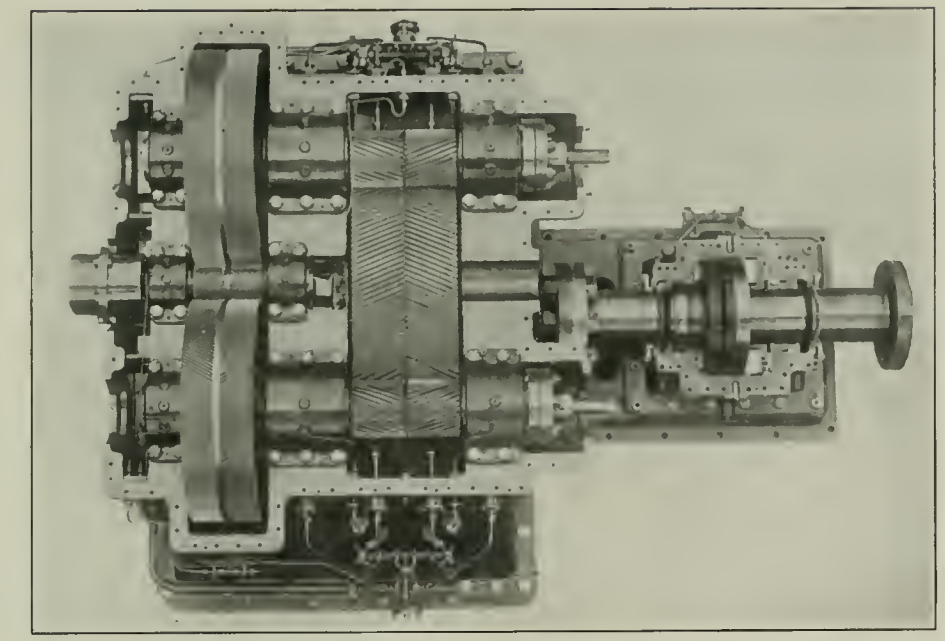
The main shop is served by two overhead travelling cranes made by Alex. Jack & Co., one capable of lifting 25 tons and the other 20 tons. In addition, there are six wall jib cranes made by the Vaughan Crane Company, each having a 20-ft. radius and capable of lifting a maximum load of 2 tons. The heavier machines are also provided with jib cranes.

In addition to the main machine and erecting shop, there is a side bay parallel to the main bay and served by one 15-ton travelling crane and one 5-ton hand traveller, both by S. H. Heywood & Co. Ltd., Reddish. It is in this bay where the gear-cutting machines are built. There is also a well-equipped tool shop in which the various cutters are made, hardened and ground. Special machinery has been installed for producing accurately the cutters required for the Sykes' gear generating machines, and after being cut, these are hardened and then ground. Particular attention has been paid to the warming and ventilating of this shop, so that the men may work under conditions of physical comfort, it being recognised that this is necessary if work of the greatest accuracy is to be turned out. The jig and tool drawing office forms a gallery in the tool shop, and in this is a Du Nord hardness-testing machine by means of which the hardness of all tools can be readily determined. There is also a pattern-makers' shop equipped with the latest forms of wood-working machinery, all of which is equipped with exhausters for withdrawing the sawdust from the machines as it is formed. All the shops are heated in winter and cooled in summer by a system of ventilation which in winter drives warm air into the shops and in summer draws fresh air through the shops. Air is heated

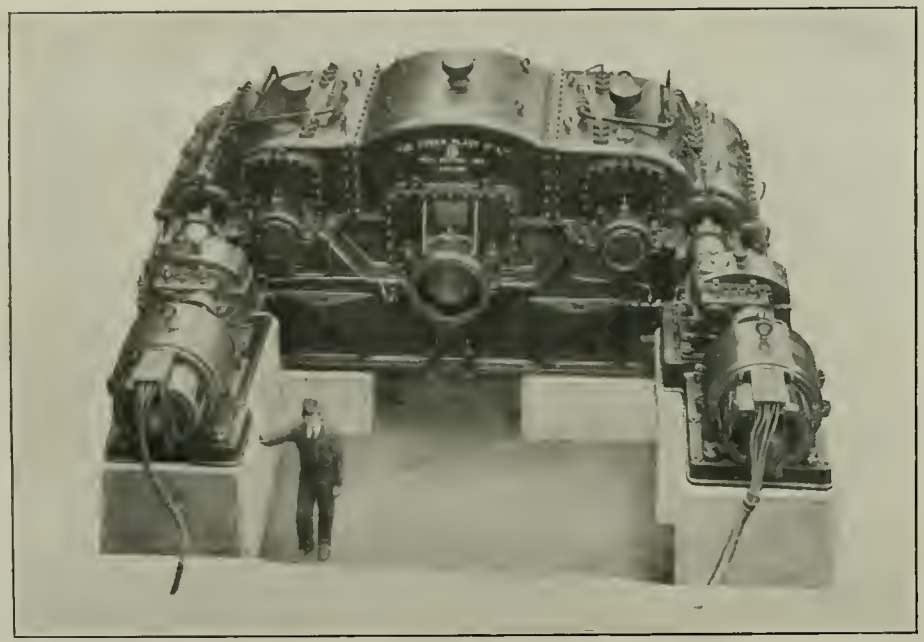
(*Continued on page 85.*)



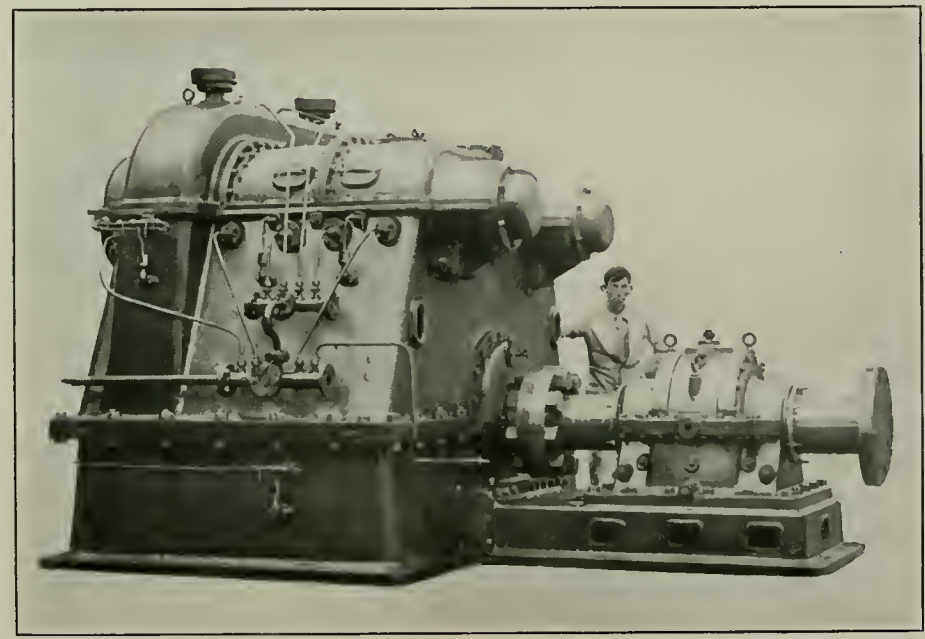
Double-Reduction Gears for Torpedo Boat Destroyer, 2,500 s.h.p. Speed Reduction, 3,000 to 380 r.p.m., with flexible Intermediate Shafts.



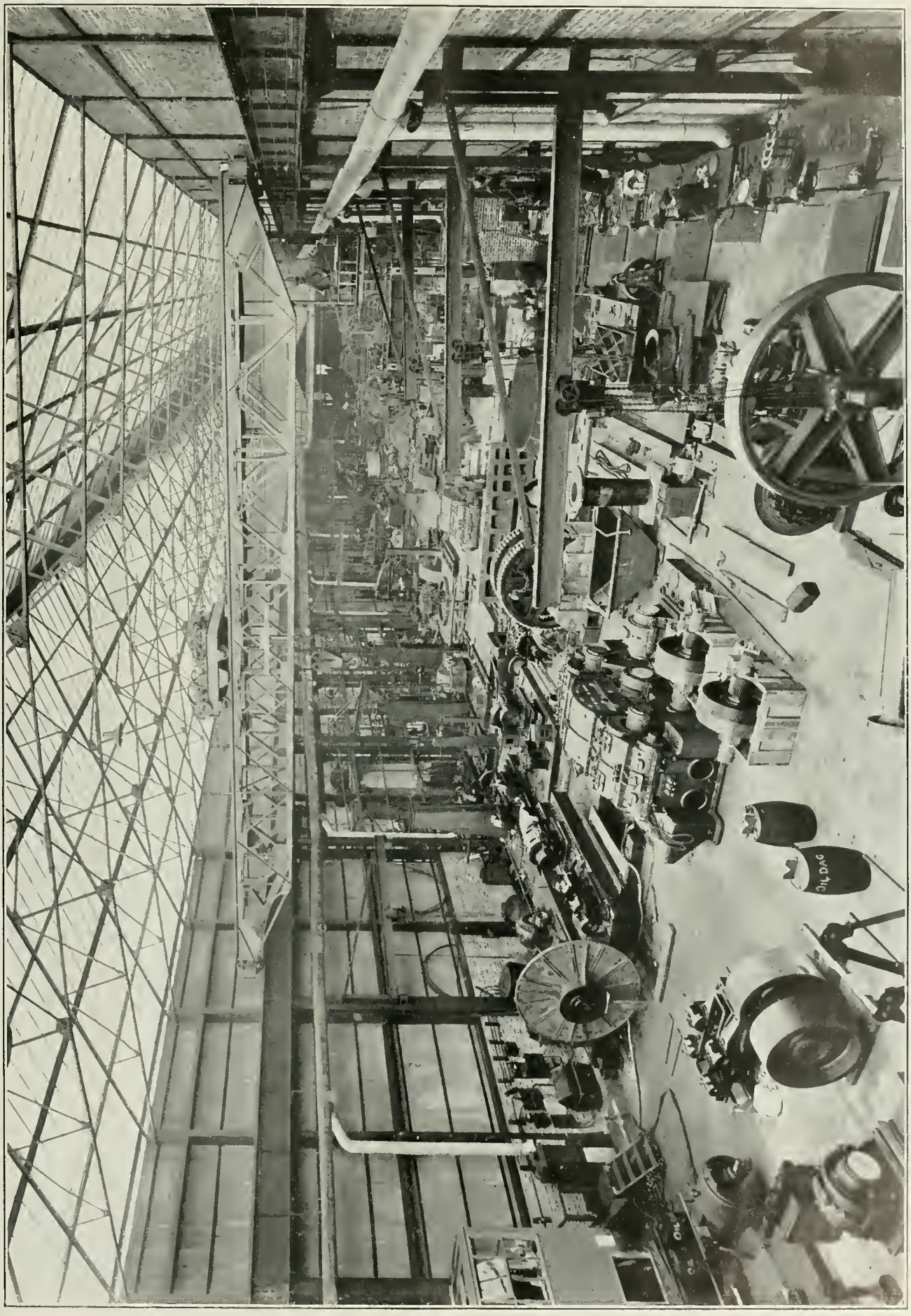
Plan of Gears shown in Illustration below with Top Cover removed showing arrangement of Michell Thrust Block.



Set of D.R. Gears 4,000 h.p., 3,600 to 85 r.p.m., driven by Electric Motors for Speed Test.

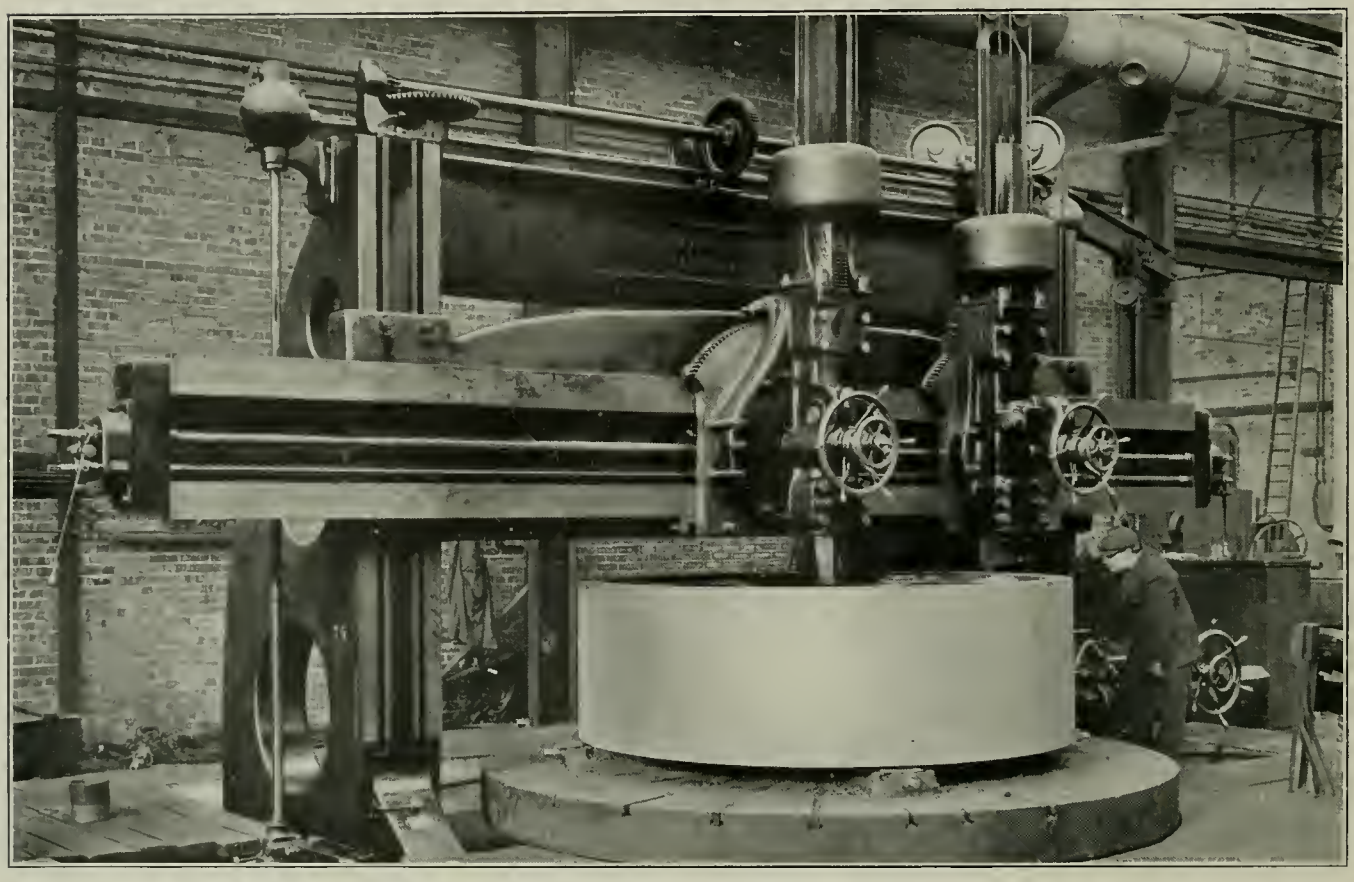


Single Pinion D.R. Marine set, 1,375 s.h.p., 4,000 to 80 r.p.m., with Michell Thrust Block.

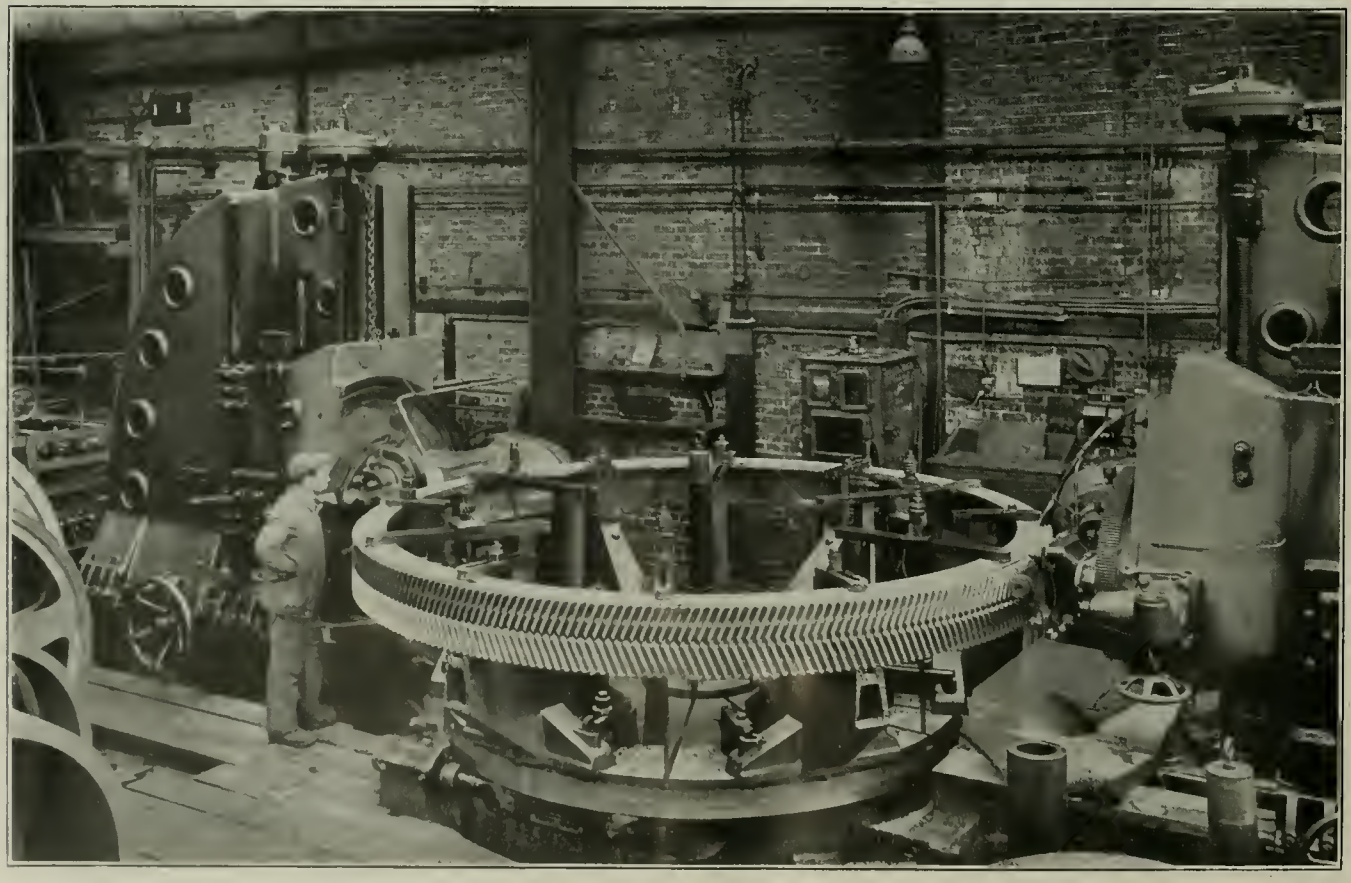


Main Shop, 500 ft. long × 70 ft. wide, of the Power Plant Co. Ltd., West Drayton, showing set of Gears for ss. "Reggestroom" in foreground.

CUTTING GEARS AT THE WORKS OF

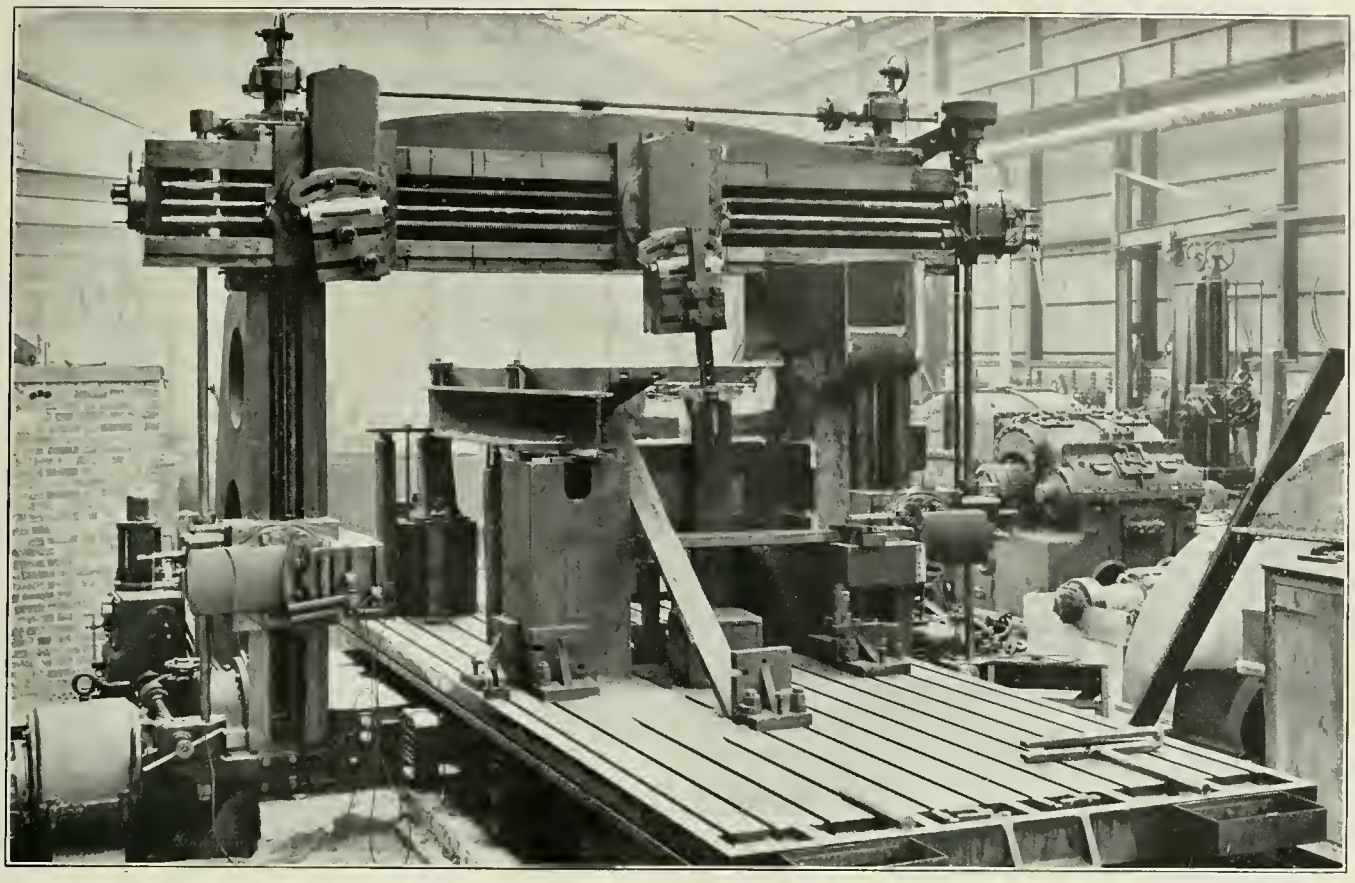


Vertical Boring Machine boring the Centre and turning the rim of large Gear Wheel.

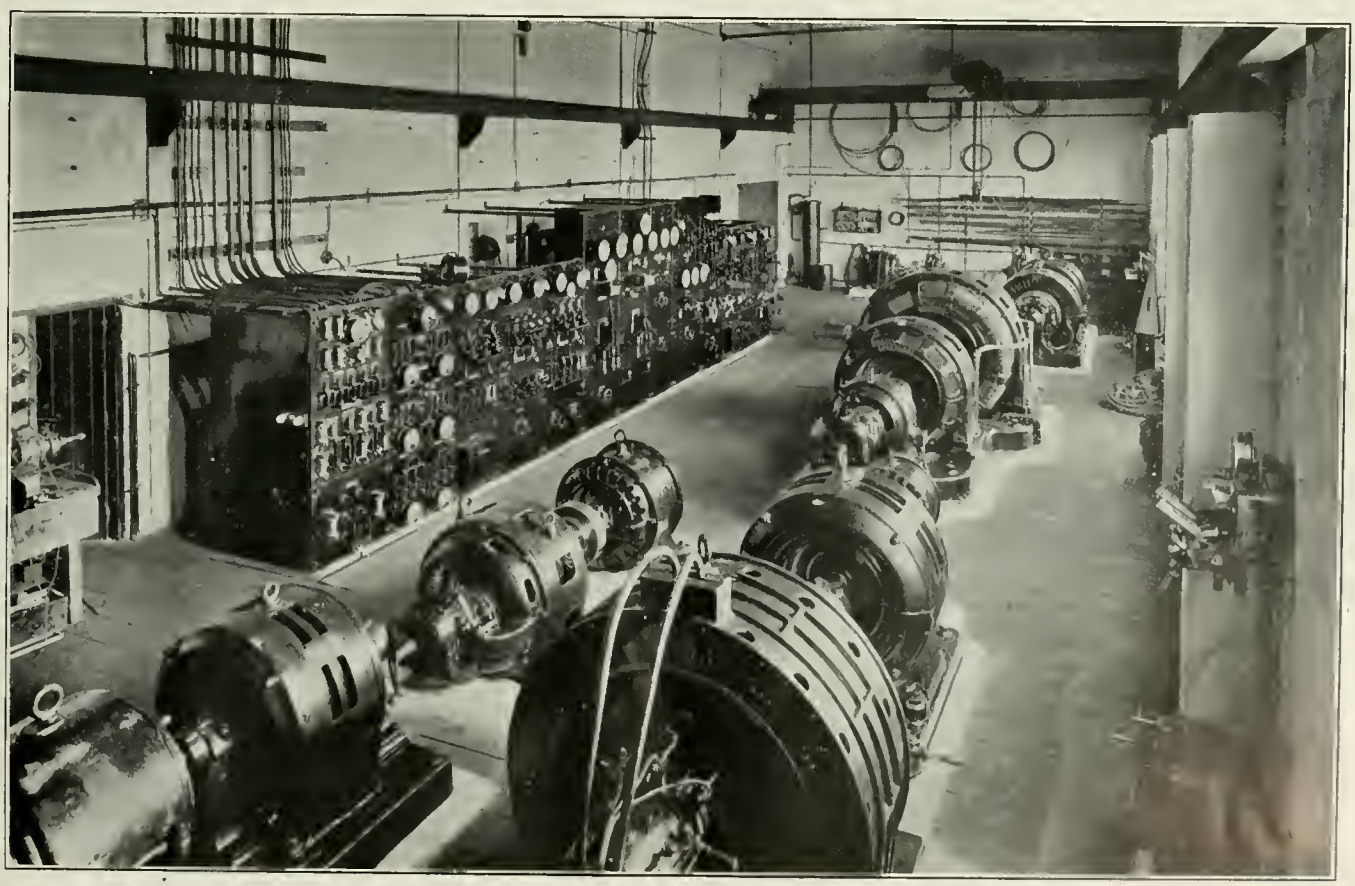


Double Hobbing Machine for cutting Teeth on large Gear Wheels.

THE POWER PLANT CO. LTD., WEST DRAYTON.

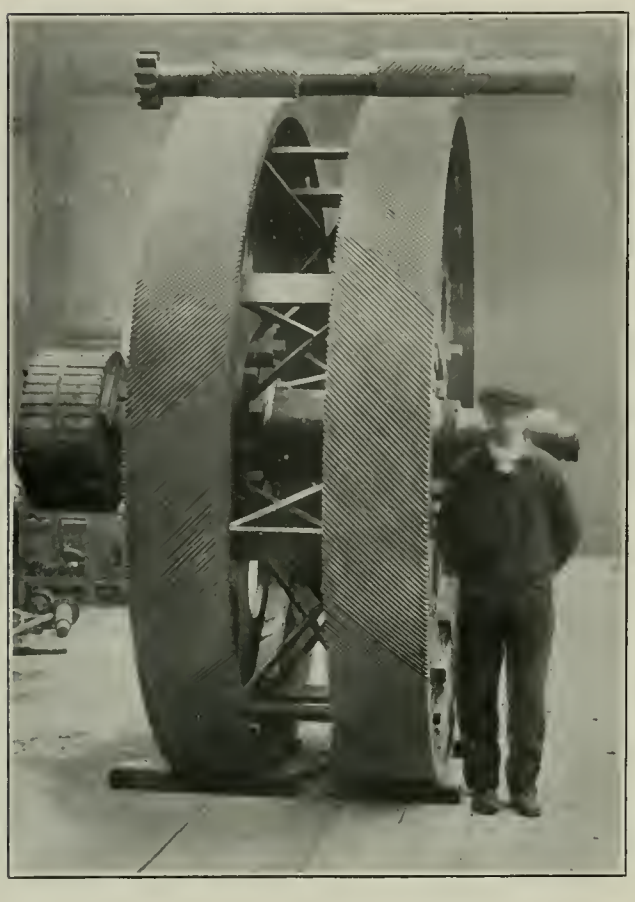


Stirk Universal Planer, also available as Slotter for Machining Internal Surfaces.

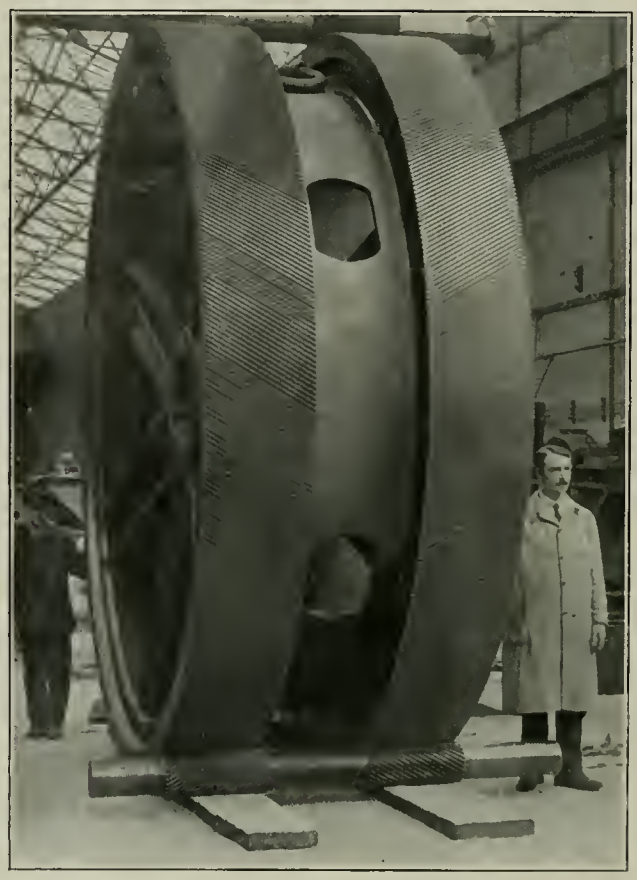


Power House of the Power Plant Co. Ltd., West Drayton.

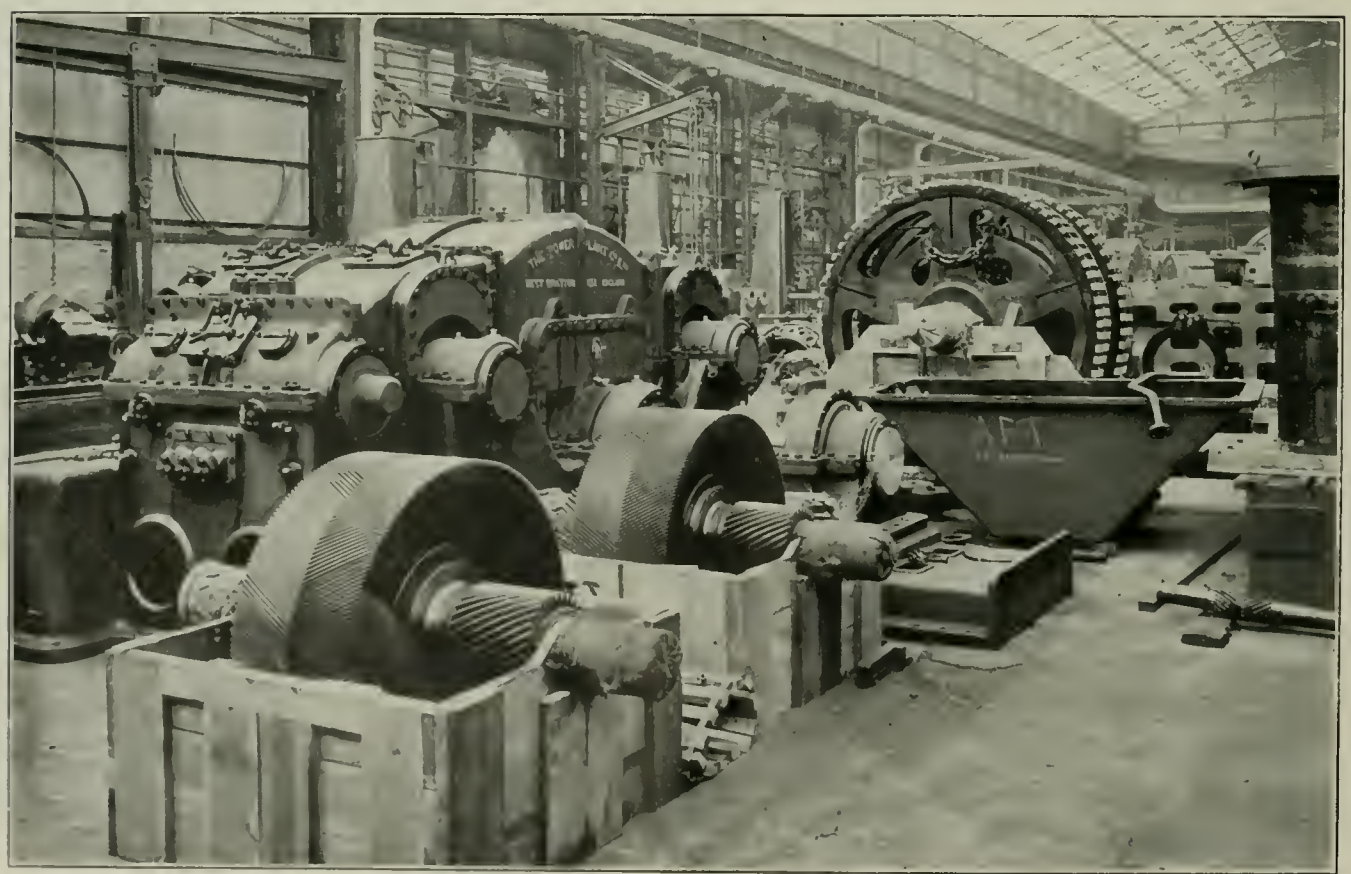
GEARS CUT BY THE POWER PLANT CO. LTD.



Single-Reduction Gears of the Cruising Turbines for H.M. Battle Cruiser "Queen Elizabeth."



Single-Reduction Gear for Merchant Ship, Two Pinion Drive; Reduction 20 to 1.



Set of Double-Reduction Gears completed and being packed for Shipment to Holland for ss. "Reggestroom," transmitting 1,800 h.p., and giving a Reduction from 4,000 to 80 r.p.m.

ACCURATE CAMS FOR INTERNAL COMBUSTION ENGINES.

The Grinding Method Making the Master Cam.

Few parts of the modern, highly efficient and powerful Diesel, semi-Diesel and heavy gas engines of to-day call for more exacting care in their manufacture than the cams which operate the different valves. Mathematically correct generation and angular relationship are of prime importance and

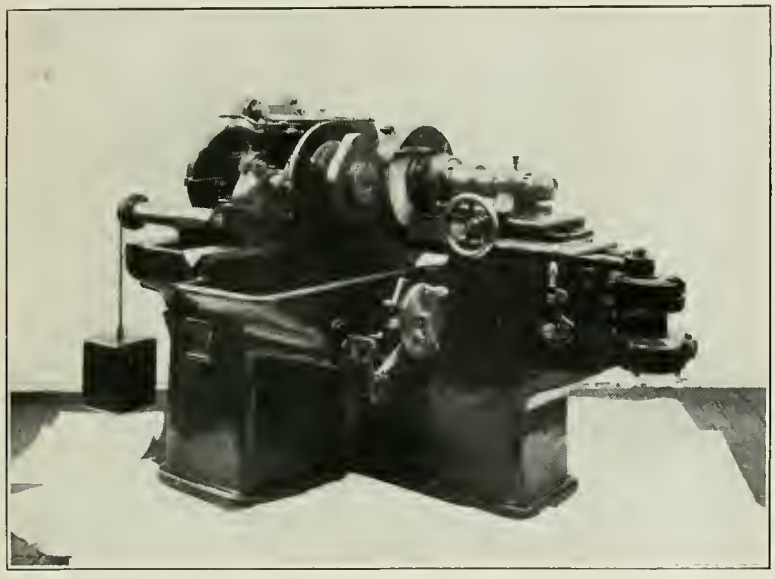


Fig. 1.—Machine for Grinding Cams up to 18 in. Peak Radius.

provide another striking example of where the precision grinding machine can be of infinite service to the engine designers and builders in giving them just that fine degree of accuracy in their product which spells all the difference in actual operation between results which are good and those which are indifferent.

In addition to the enhanced accuracy obtainable by the grinding method, the finished cam is turned out with a high quality finish which is undeniably more durable in service than the best which can be produced by any other method.

A grinding machine specially designed for this work is shown in Fig. 1. Cams up to 18 in. peak radius can be accommodated on this machine. A similar design of machine with smaller capacity for cams up to 8 in. peak radius is shown in Fig. 3.

The method of operation on both machines is as follows:—It is first of all necessary to make a dead accurate model the exact shape and size of the cam required. This model can be made in sheet metal $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in thickness and is then mounted on the work arbor shown in Fig. 7 (page 63), with the master cam to be generated to the rear of it. The grinding wheel on the main spindle is removed and a roller or disc (supplied with the machine and the same diameter as the grinding wheel) mounted on the spindle; this arrangement is shown in diagram form in Fig. 8. The direction of pull of the balance weight is now arranged to bring the model cam (D) and 16 in. diam. disc (F) in contact, and all is now ready to proceed with the grinding to shape of the master cam (E), when the auxiliary grinding spindle with 3 in. diam. wheel has been brought into action at (G).

Assuming now that the master cam has been ground to shape, the auxiliary grinding spindle is removed, and the 3 in. diam. roller is substituted for the auxiliary grinding spindle used to generate the master cam. The pull of the balance weight is then reversed to bring the master cam and roller in contact as shown in Fig. 9 (page 64).

The 16 in. diam. grinding wheel is then substituted for the metal disc previously used as a rubber. The cam to be ground is carried on a work arbor, and the operation of grinding to shape then proceeds in the ordinary way by means of the automatic ratchet feed to the grinding wheel, reciprocating movement being given to the wheel slide, traversing the wheel backwards and forwards across the face of the cam.

The headstock carrying the cam spindle has a swinging motion only, and once a correct master cam has been generated no variation in the shape of the engine cam as given by the master cam can occur, except by variation in the diameter of the grinding wheel due to wear.

The diameter of the grinding wheel supplied with the machine is 16 in., and experience has shown that the wheels can be worn down to 11 in. diam. before the error in the cam becomes greater than can be allowed. The error in the cam due to grinding wheels becoming too small is that more material is left on the rise and fall portions of the cam, the important positions of the cam, *i.e.*, the commencement of the valve opening, the closing, and the height of lift not being affected. Smaller wheels can, of course, be used for roughing-out purposes, finishing with the larger wheels to obtain greater accuracy.

It may be further stated that the diameter of the grinding wheel used is dependent on the diameter of the disc or roll used when developing and grinding the master cam. For particulars of this variation see Fig. 8. If cams are required with a hollow side it naturally follows that the

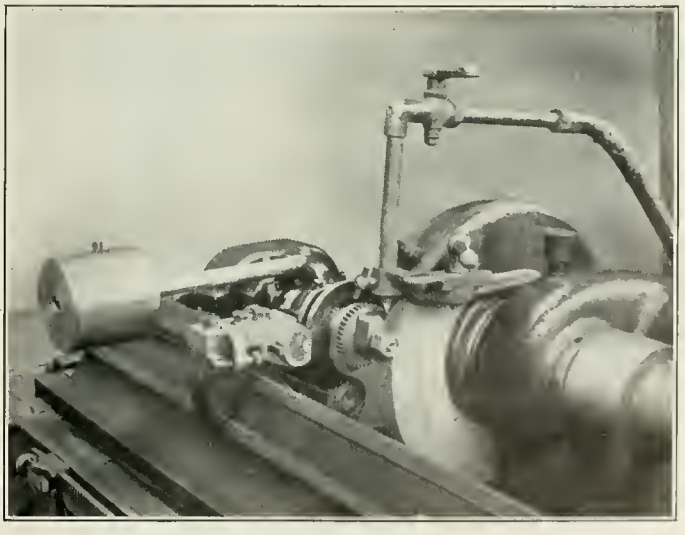


Fig. 2.—Simple Attachment for Grinding Cams as fitted to ordinary Grinding Machine.

largest roll that can be used is fixed by the radius of the hollow side on the cam.

The attachments shown in Figs. 2, 4, 5 and 6 illustrate the application of the principle embodied in the single-purpose

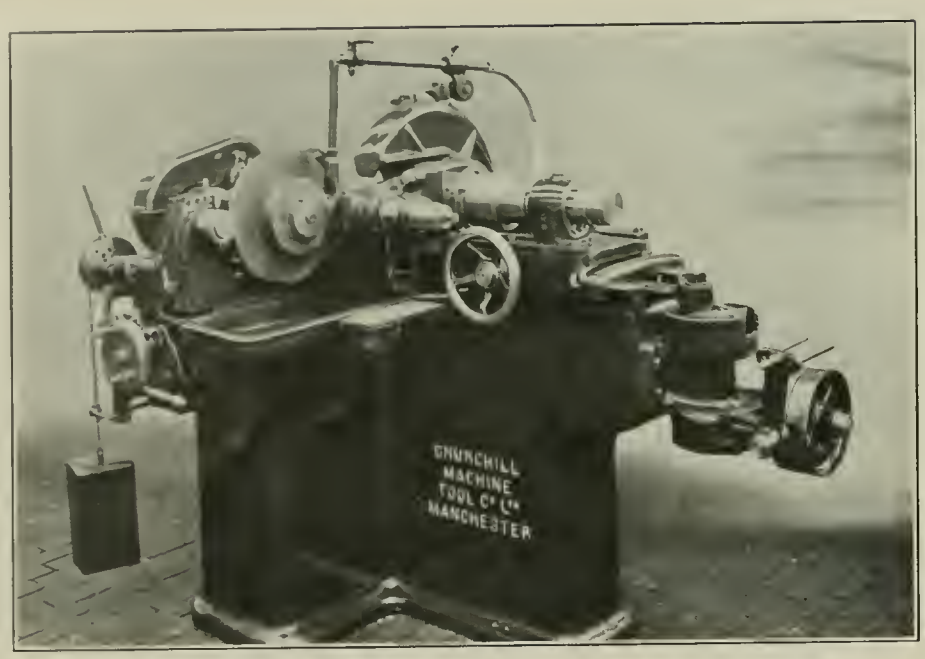


Fig. 3.—Machine for Grinding Cams up to 8 in. Peak Radius.

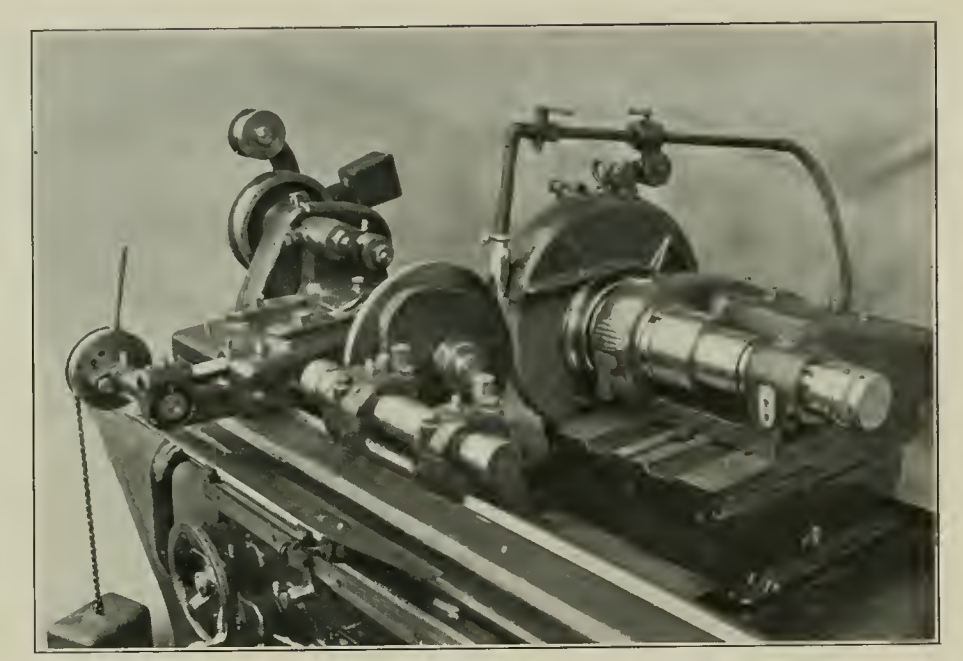


Fig. 4.—Cam Grinding Attachment as fitted to Cylindrical Grinding Machine.

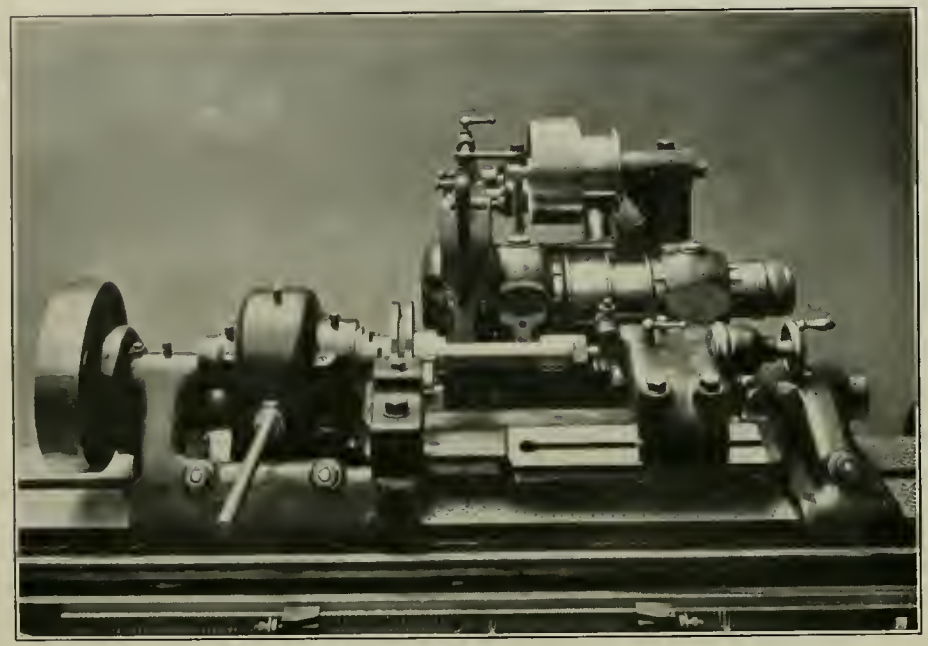


Fig. 5.—Attachment embodying the Features of the Cam Grinding Machine for fitting to Ordinary Cylindrical Grinder.

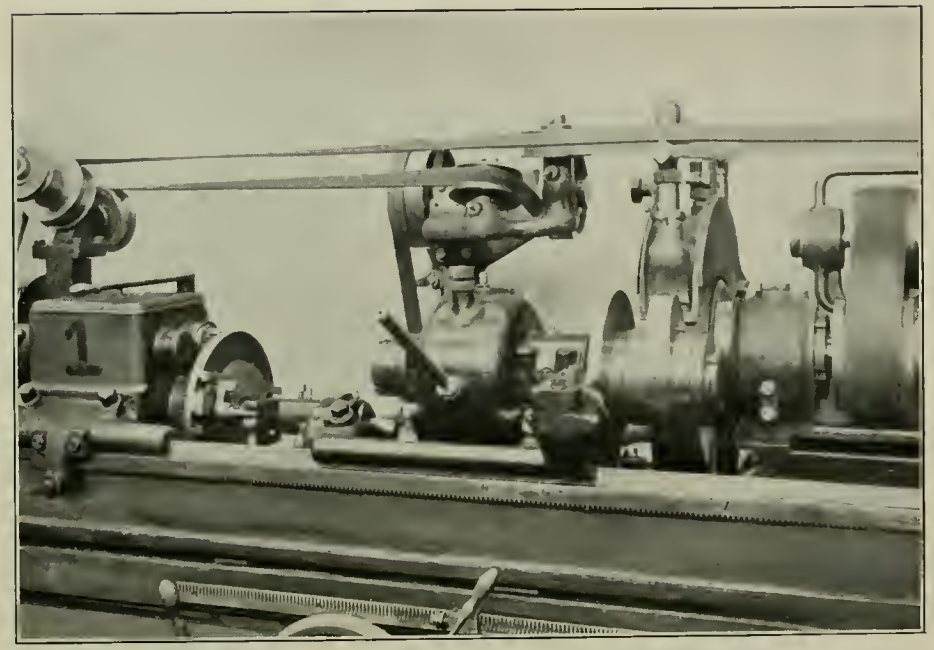


Fig. 6.—Arrangement of Belts for Driving Cam Grinding Attachment on Ordinary Grinding Machine.

machine applied to two different sizes of plain grinding machines.

When the number of cams to be produced is not large enough to justify the installation of the machines shown in Figs. 1 and 3, these attachments will render good service, although it is advisable not to lose sight of the fact that they tie up for the time being a more expensive tool.

ELECTRIC AUXILIARIES ON MERCHANT SHIPS.*

(*Concluded from page* 35.)

All references indicate that at the present time direct current is being generally adopted for auxiliary power on merchant

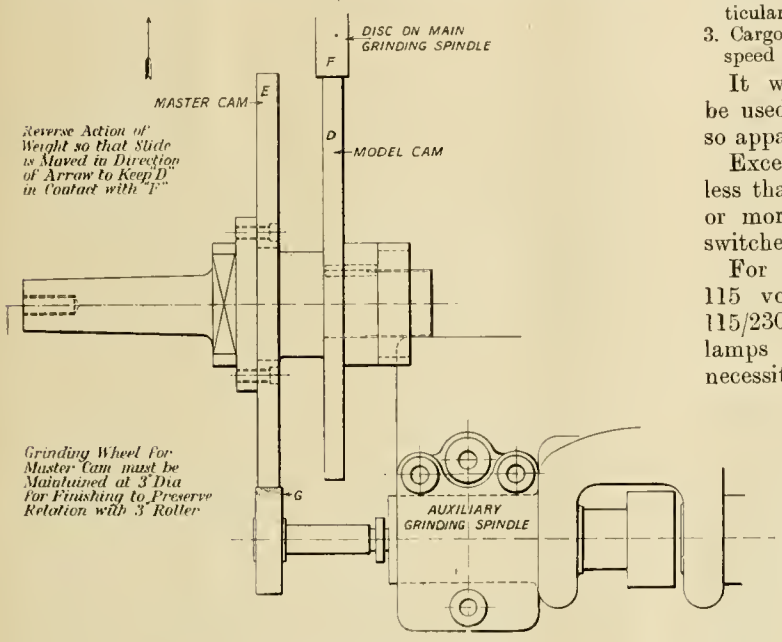

DISC ON MAIN GRINDING SPINDLE
F
E
MASTER CAM
D
MODEL CAM
Reverse Action of Weight so that Slide is Slaved in Direction of Arrow to Keep D in Contact with F
Grinding Wheel For Master Cam must be Maintained at 3" Dia For Finishing to Preserve Relation with 3" Roller
G
AUXILIARY GRINDING SPINDLE

Fig. 7.—Diagram showing Model and Master Cams as mounted on Grinding Machine.

ships. Some time ago there was considerable discussion as to the relative merits of alternating current and direct current. The following tabulation will show why direct current is being used to the greater extent :—

CARGO SHIPS.

DIRECT CURRENT.

Arguments For.	*Arguments Against.*
1. Simple wiring.	1. Commutators require some attention.
2. Any speed control easily obtained.	
3. Equally suitable for continuous and intermittent duty.	

ALTERNATING CURRENT.

1. Lower cost of motors and generators.	1. Wiring more expensive.
2. Absence of commutators.	2. Unsuitable for variable speeds necessitating hydraulic or other gear for winches and windlasses.

TANKERS.

DIRECT CURRENT.

1. Simple wiring.	1. Commutators require some attention.
2. Equally suitable for continuous and intermittent duty.	2. Little necessity for variable speed motors. Special cases could be fitted with hydraulic or direct current power furnished from small motor-generator set.
3. Speed of cargo pump can be varied to suit pressures and most efficient rate.	3. Special precautions must be taken to ventilate motors in tank room.

ALTERNATING CURRENT.

Arguments For.	*Arguments Against.*
1. Lower cost of motors and generators.	1. Wiring more expensive.
2. Absence of commutators, particularly desirable in pump room.	2. Special motors necessary to change speed.
3. Cargo handled by constant speed pumps.	

It would seem that for cargo ships direct current can be used to the greatest advantage. On tankers this is not so apparent.

Except in the smaller ships, it is desirable to use not less than 230 volts. The lower voltage necessitates large or more expensive control; also the cost of wiring and switches is greater.

For lighting, the arguments seem to be in favour of 115 volts. This necessitates the installation of a small 115/230 volt motor-generator set. The use of incandescent lamps for 230 volts is not recommended. They are of necessity built with a very fine filament and are, therefore, less substantial, and further, are not easily procured in seaports.

It is impossible to speak too forcibly on wiring and installation. A great deal of the criticism of electrical apparatus when thoroughly investigated has been found to be directly due to faulty, careless, slipshod methods of wiring and installation.

Operation.

To study the relative merits of ships' auxiliaries, it is necessary to consider the part which they play in the economic operation of the ship. For certain special types of ships designed and built to operate

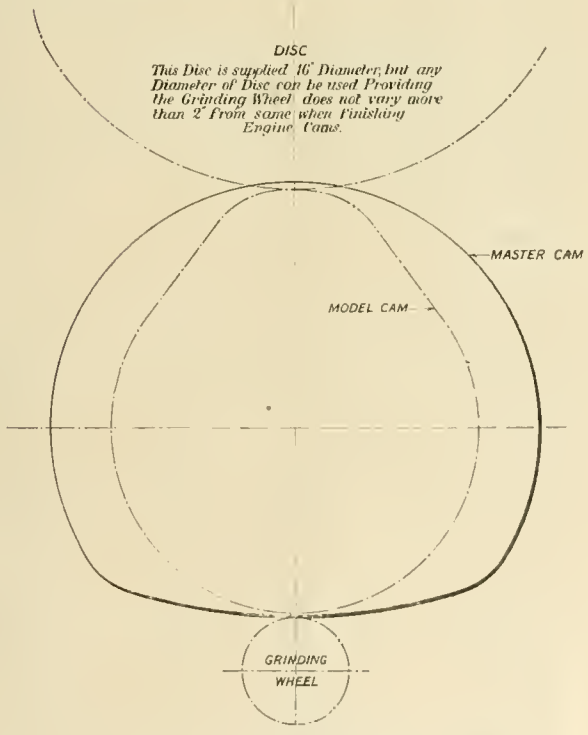

DISC
This Disc is supplied 16" Diameter, but any Diameter of Disc can be used Providing the Grinding Wheel does not vary more than 2" From Same when Finishing Engine Cams.
MASTER CAM
MODEL CAM
GRINDING WHEEL

Fig. 8.—Diagram showing position of Master and Model Cams for Grinding Master Cam.

* Abstract of a paper read at the twenty-ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 17 and 18, 1921, by Mr. Edgar D. Dickinson.

for some particular service, such as tankers and lake ore carriers, it is not difficult to show definitely why a certain installation will give the best return on the investment.

In the cargo ship, however, the problem is not so clearly cut. While it is true that a certain number of ships may be designed with the intention of travelling particular trade routes and handling a special cargo, it is often found that their schedule must be modified. Therefore the general cargo ship must be built to handle all kinds of cargo, and at best, therefore, the apparatus with which it is equipped is somewhat of a compromise.

It is not possible to make any exact general statement as to the proportions of the various items constituting the cost of operating merchant ships. They may, however, be listed as follows :—

1. Fuel and lubricating oil at sea and in port.
2. Port charges including wharfage, lighterage, pilot fees, canal dues, stevedoring, tug-boat charges, &c.
3. Salaries and subsistence.
4. Upkeep and repairs, deck department.
5. Upkeep and repairs, engine department.
6. Supplies, engine, deck and steward's departments.
7. Insurance.
8. Loss and damage.

If we assume a 7,800 d.w. ton ship fitted with 2,500 h.p. steam turbine on a schedule for coastwise service between New York and Seattle, stopping at San Pedro to load and discharge cargo and making four round trips per year, the charges might be approximately as follows :—

OPERATING DISBURSEMENTS.

	Loaded both Ways.	Percentage.	Loaded Going, One-Half. Loaded Returning.
	$		$
1. Fuel	81,300	14·8	81,300
2. Port charge	290,420	52·9	211,020
3. Salaries	60,490	11·0	60,490
4. Repairs, deck	10,000	1·8	10,000
5. Repairs, engine	20,000	3·7	20,000
6. Supplies	20,250	3·7	20,250
7. Insurance	62,400	11·4	62,400
8. Loss and damage	3,650	0·7	3,650
Total	548,510	100·0	469,110

Many of these would be affected by electrification of auxiliaries, and the net reduction would be very considerable.

1. *Fuel, &c.*—In the usual marine geared-turbine installation with steam auxiliaries, the pressures generally carried are as follows :—

	Gauge.
Boiler pressure	210 lb.
Turbine	200 lb.
Auxiliary steam line	100 lb.
Auxiliary exhaust	10 lb.
Superheat	75° Fahr.

The auxiliary exhaust steam is used to heat the feed water, and that which is in excess of feed-water heater requirements is by-passed to the main condenser.

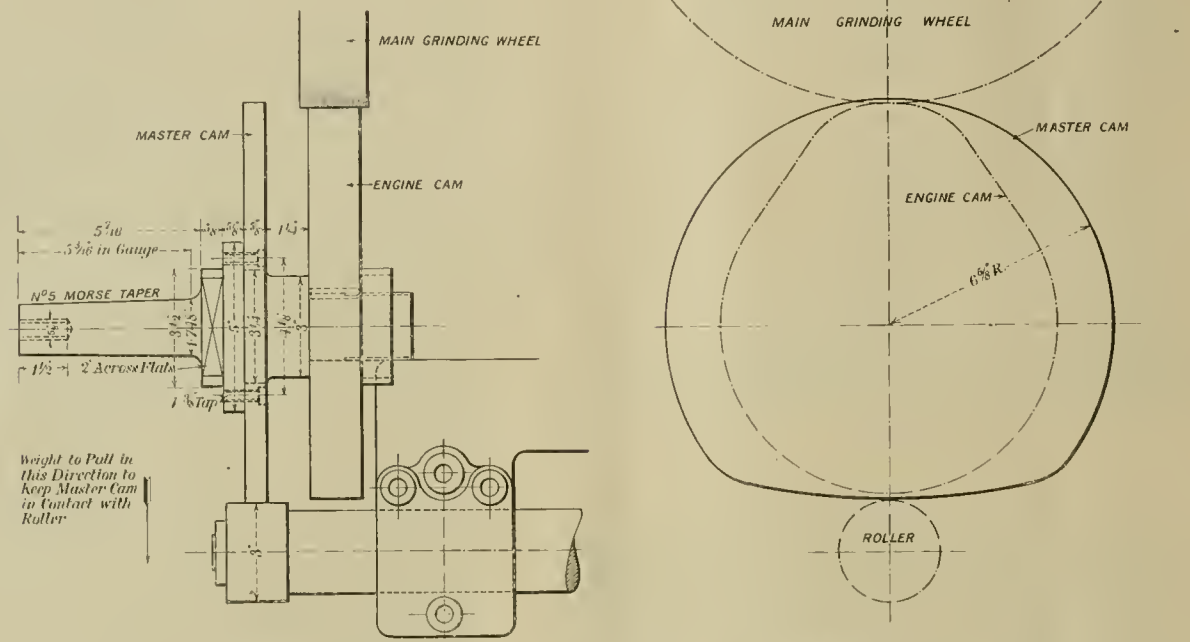


Fig. 9.—Diagram showing Grinding of actual Engine Cams from Master Cam. (*See page* 61.)

Under full power, a fair operating average for this type of installation is as follows :—

Steam Consumption per Hour—

	Lb.
Main turbine, 2,500 h.p.	28,875
Steam auxiliaries at sea	12,500
Total steam consumption	41,375

Steam per Shaft Horse-Power Hour, all Purposes—

$$\frac{41,375}{2,500} = 16{\cdot}5 \text{ lb.}$$

Boiler Evaporation.—With water-tube boilers, Howden draught system, feed water delivered to boilers at 220 deg., 210 lb. gauge pressure and 75 deg. superheat, a conservative estimate of the actual evaporation per lb. of fuel oil is taken at 13·5 lb.

Fuel Consumption—

Fuel per hour $= \frac{41,375}{13{\cdot}5} = 3,065$ lb. .... = 9·6 barrels.
Fuel per day, 73 560 lb. .... = 32·8 tons.
Fuel in barrels, per day .... = 230 barrels.

Fuel per Shaft Horse-Power Hour—

$$\frac{3,065}{2,500} = 1{\cdot}23 \text{ lb.}$$

Fuel in Barrels per Knot—

Assuming a speed of 10·5 knots, $\frac{9{\cdot}6}{10{\cdot}5} = 0{\cdot}915$ barrel per knot.

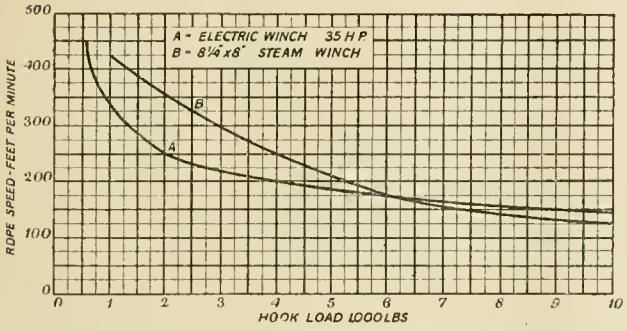
The economy to be gained through the application of electrically-driven auxiliary machinery, in fuel consumption alone, may readily be seen from the following estimates :—

Superheat, 75° Fahr.

Heating Feed Water.—The proposed method would be to extract sufficient steam from the turbine for feed-water heater requirements.

Steam Consumption per Hour—

	Lb.
Main turbine, 2,500 h.p.	30,600
Turbine generator	2,640
Air ejector	1,000
Total	34,240



Characteristic Curves of Electric and Steam Winches.

NOTE.—3,600 lb. per hour steam will be extracted from main turbine at about 10 lb. gauge to heat feed water.

Steam per Shaft Horse-Power Hour, all Purposes—

$$\frac{34,240}{2,500} = 13{\cdot}7 \text{ lb.}$$

Boiler Evaporation.—Estimated for comparative purposes at 13·5 lb. per lb. of fuel. With the lesser quantity of steam to generate, however, the boiler efficiency would be improved in actual practice.

Fuel Consumption—

Fuel per hour $= \frac{34,240}{13{\cdot}5} = 2,536$ lb. .... $= 7{\cdot}9$ barrels.
Fuel per day, 60,864 lb. .. .... $= 27$ tons.
Fuel per day, in barrels .... $= 189$ barrels.

Fuel per Shaft Horse-Power Hour—

$$\frac{2,536}{2,500} = 1{\cdot}01 \text{ lb.}$$

Fuel in Barrels per Knot—

Assuming a speed of 10·5 knots, $\frac{7{\cdot}9}{10{\cdot}5} = 0{\cdot}75$ barrel per knot

The application of high superheat, well within the limits of present-day design, and electric auxiliaries present a very interesting and high economic value in ship propulsion.

Superheat, 200° Fahr.

Steam Consumption per Hour—

	Lb.
Main turbine, 2,500 h.p. .	27,000
Turbine generator	2,400
Air ejector	1,000
	30,400

NOTE.—3,000 lb. per hour steam will be extracted from main turbine at about 10 lb. gauge to heat feed water.

Steam per Shaft Horse-Power Hour, all Purposes—

$$\frac{30,400}{2,500} = 12{\cdot}15 \text{ lb.}$$

Boiler Evaporation—

Assumed at 13 lb. per lb. of fuel.

Fuel Consumption—

Fuel per hour $= \frac{30,400}{13} = 2,340$ lb. .... $= 7{\cdot}33$ barrels.
Fuel per day, 56,200 lb. .... $= 25{\cdot}1$ tons.
Fuel in barrels, per day .... $= 176$ barrels.

Fuel per Shaft Horse-Power Hour—

$$\frac{2,340}{2,500} = 0{\cdot}936 \text{ lb.}$$

Fuel in Barrels per Knot—

Assuming a speed of 10·5 knots, $\frac{7{\cdot}33}{10{\cdot}5} = 0{\cdot}698$ barrel per knot.

These estimates show the saving in fuel consumption by the use of electric auxiliaries, as follows :—

Saving in Fuel Consumption (at Sea)—

Steam auxiliaries, 230 barrels.
Electric auxiliaries, 189 barrels, 17·3 per cent.
Electric auxiliaries, with 200° Fahr., 176 barrels, 23·5 per cent.

Saving per Year—

208 days at sea, oil at $1·50 per barrel.
Electric auxiliaries, 8,320 barrels at $1·50= $12,480.
Electric auxiliaries, with 200° Fahr. superheat, 11,250 barrels at $1·50= $16,900.

In the estimate, an allowance was made of 40 barrels per day in port. With electric auxiliaries and economic engine-room machinery, it should be possible to reduce this by one-half.

157 days × 20 lb. × $1·50 = $4,710.

With a good system in the engine room, the lubricating oil required would be greatly reduced.

Port Charges.—In giving thoughtful consideration to improving the earning power of a ship, it will be recognised as essential to decrease its idle time, as certain charges are continuous, whereas the ship is actually earning money only when travelling between ports. When it is realised that the average cargo ship makes only about 36,000 miles per year and that at an average sped of 10 knots, which means that she is at sea only about 150 days out of a year, it is very evident that there is a big field for improvement.

Port charges estimated for the coastwise schednle mentioned above are as follows :—

	New York.	Colon.	Los Angeles.	San Francisco.	Seattle.	Total.
	$	$	$	$	$	$
(*a*) Wharfage	7,800		1,560	3,120	3,120	15,600
(*b*) Lighterage			....	....		
(*c*) Pilots' fees	202·56	..	200	250	.	652·56
(*d*) Stevedoring....	7,800	....	1,560	3,120	3,120	15,600
(*e*) Tugboat charges	100	....	....	200	....	300
(*f*) Canal dues	....	4,150	....	....	....	4,150

Total per trip .... 36,302·56
Total per year (four round trips) .... 290,420·48

By the use of the most suitable electric machinery, it should be possible to reduce the item of port charges 10 per cent. In the estimate given above this would mean approximately $30,000 per year saving.

The assured reliability of proper electrical machinery in the engine room, along with the elimination of a large amount of piping carrying high-pressure steam, should have a direct bearing on the insurance rate. Indirectly, by reducing the loss of steam, it should be possible to maintain the water in the boilers in almost perfect condition. This should still further add to the safety of a ship. It would seem to be justifiable to expect that the insurance premiums can be decreased about 5 per cent. ; this would mean a saving of approximately $3,000 per year.

The sum of the different gains mentioned above totals $55,190 per year. The amount of saving that can be shown by other estimates will naturally vary with conditions.

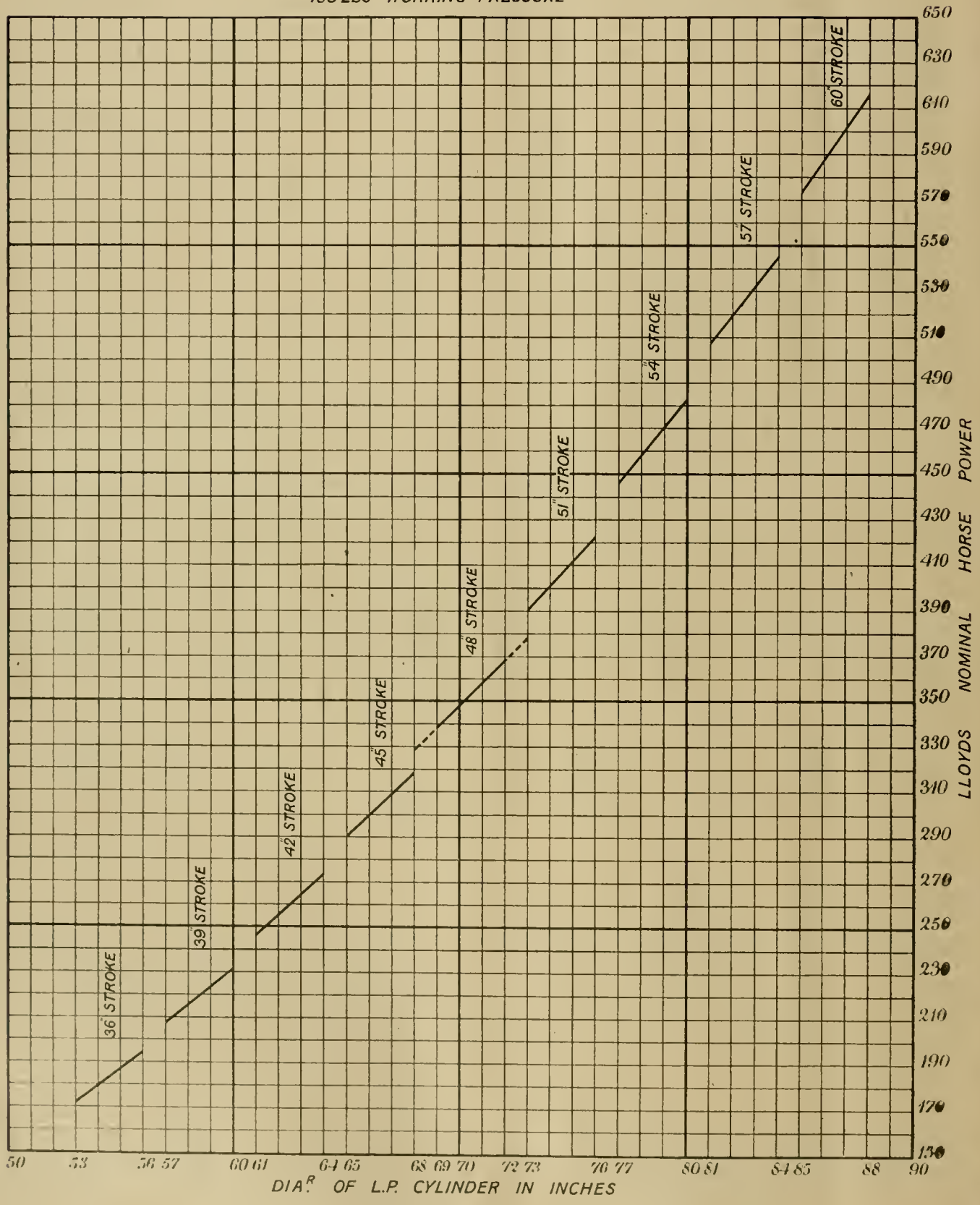


Diagram for Determining Size of Machinery, (*See opposite page.*)

CARGO BOAT MACHINERY.

The Use of Lloyd's Register Nominal Horse-Power Rule.

It may be taken as an axiom that the North East Coast is the home of the cargo steamer as evidenced by the fact that the council and members of the North East Coast Institution of Engineers and Shipbuilders in 1917 drafted a Guidance Specification for Reciprocating Triple Expansion Marine Engines for Cargo Vessels, which was adopted by the Institution and generally accepted by the manufacturers of cargo boat machinery in the district. The specification was based on the best practice of the day and the district, and is known as "The North East Coast Institution Guidance Specification (1917) Triple Expansion Engines for Cargo Vessels."

In the interval between 1917 and 1919 the specification was revised and brought thoroughly up to date so as to command the confidence and promote the ultimate interest of all concerned, resulting in the adoption of what is now known as "The North East Coast Institution Guidance Specification (1919) Triple Expansion Engines for Cargo Vessels," which refers to engines up to 3,500 i.h.p. normal on service.

Two alterations were made to the 1917 specification, *i.e.*, first, the substitution of a new rule for the indicated horse-power: secondly, the adjustment of the referred mean pressure to the low-pressure cylinder.

It is the intention of the writer to analyse the rules affected by these two specifications so as to indicate the results obtained by the adoption of either specification when deciding upon a suitable size of machinery for a given-sized cargo steamer.

The sizes of engines in general use for cargo steamers have the stroke ranging from 36 in. up to 60 in. inclusive.

The range in the diameter of the low-pressure cylinder is usually about 4 in. for each successive stroke; in the case of the 48 stroke engine it is frequently made with a range of 7 in. in diam. of the low-pressure cylinder, depending considerably on the ideas of the designer as to the number of revolutions for a given set of patterns.

Lloyd's nominal horse-power rule is a convenient and reliable rule to use when comparing different proportions of engines, steaming weights, &c., being as it is unaffected by the revolutions: consequently it is in extensive use as forming a basis for the selling price of marine machinery, being a guide as to the capacity of the engine

The rule is as follows—

$$N H P = \frac{W P + 590}{1500}\left(\frac{L^2 \sqrt{S}}{100}\right) = C \times \frac{(L^2 \sqrt{S})}{200}.$$

Where N H P = Nominal horse-power.
W P = Boiler pressure in lbs. per square inch.
590 and 1500 are numbers to be used in finding C suitable for any given working pressure, for working pressures of 160 lb. and upwards.
L = Diameter of low-pressure cylinder in inches.
S = Stroke of piston in inches.
100 = Divisor governing capacity of engine.
C = Constant of first portion of rule.

(*See Diagram opposite.*)

Assuming 180 lb. working pressure as a basis for triple expansion marine engines—

Then $\frac{180 + 590}{1500} = \frac{770}{1500} = \cdot 5133$ = value of C required;

$$\therefore \quad \cdot 5133\left(\frac{L^2 \sqrt{S}}{100}\right) = N H P \text{ of engine.}$$

The guidance specification (1917) rule for indicated horse-power is $$I H P = \frac{L^2 S N}{700}.$$

Where I H P = Indicated horse-power.
L = Diameter of low-pressure cylinder in inches.
S = Stroke of piston in feet.
N = Revolutions per minute.

Where $N = 32\frac{(S + 4)}{S}$.

700 = constant governing the indicated horse-power, and based on the assumption that the referred mean pressure to the low-pressnre cylinder = 30 lb. M E P.

Note.—This 30 lb. is usually the referred pressure obtained with engines of tramp steamers.

The guidance specification (1919) rule for indicated horse-power is $$I H P = \frac{L^2 (S + 4)}{20}.$$

Where I H P = Indicated horse-power.
L = Diameter of low-pressure cylinder in inches.
S = Stroke of piston in feet.
20 = Constant governing the horse-power and based on the assumptlon that the referred mean nressure to the low-pressure cylinder = 32·8 lb. M E P.

Note.—This 32·8 lb. is usually the referred mean pressure obtained with engines of cargo steamers of the present day. The ratio of cylinders adopted as a basis for both rules and with a working pressure of 180 lb. are approximately as follows:—

H P = 1·0 · M P = 2·74 L P = 7·5
M P = 1·0 L P = 2·74.

When the cuts-off at service power approximate to—

H P = 57 per cent. M P = 57 per cent.
L P = 55 per cent.

The following Table I gives the revolutions as found by the formulæ for a given stroke of engine and the revolution generally used in designing the machinery for service conditions—

S = Stroke of piston in inches.
N F = Revolutions per minute as ascertained by formulæ.
N D = Revolutions per minute used when designing.

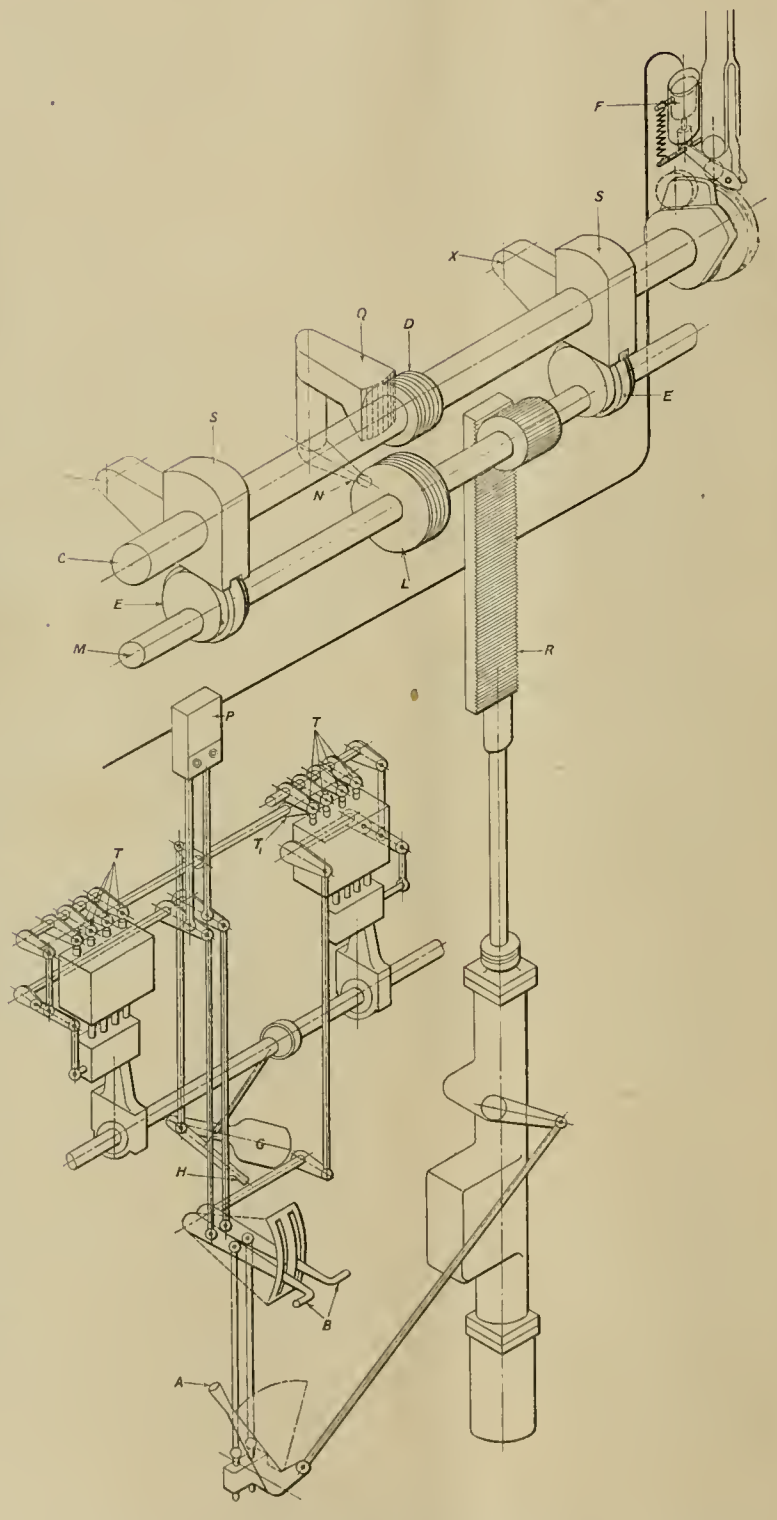
(*To be continued.*)

Table I. Showing revolutions of engine as determined by the formulæ and values generally used in designing the engine.

Stroke in inches	36	39	42	45	48	51	54	57	60
Revolutions per rule, N.F.	74·6	71·4	68·5	66·1	64	62·1	60·5	59	57·6
Revolutions adopted, N.D.	75	72	70	68	66	64	62	60	58
Piston speed, ft. p.m.	450	468	490	510	528	545	558	570	580

The bearings S for camshaft C are pivoted at X, and are therefore free to move in a vertical direction. This movement is controlled by manœuvring shaft M, which is carried directly under camshaft C and on which eccentrics E are mounted beneath each bearing S.

When engine is reversed from ahead to astern, lever A is moved to other end of quadrant, rack R moves upward, and manœuvring shaft M rotates, this causes camshaft C to drop. After one-third revolution of shaft M the cams have dropped clear of rollers and scroll L moves camshaft in aft direction through arm N, toothed quadrant Q, and grooved drum D by an amount sufficient to bring astern cams under rollers. The last part of revolution of shaft M raises camshaft into its original position, and the engine is ready to start astern. To start up engine, the master air valve is opened, lever A set in position required, and control lever B brought down to bottom of quadrant. This movement depresses fuel pump tappets T, and holds suction valves open for whole stroke of pump, so that no fuel passes delivery valves. It also opens piston valves in chest P; these valves admit air to starting valve gear actuating cylinders F, thus causing starting valve rollers to come in contact with cams and air is admitted to all cylinders.



Control and Reversing Mechanism for Single-Acting 4-Stroke Cycle North British Diesel Engine.

When engine has speeded up on air, levers B are thrown up towards top of quadrant past no fuel position. This movement lifts fuel pump tappets off suction valves for part of pump stroke and allows oil to be admitted to cylinders, and also cuts off air from starting valve gear actuating cylinders F from engine cylinders, and lifts rollers off starting cams. The engine is now completely controlled by levers B, which control suction valves of fuel pumps, and thus regulates amount of oil pumped to cylinders.

The governor G, which is driven off fuel pump shaft, is set so that when the engine speed becomes excessive lever H is engaged and carried upwards. This brings into operation a secondary set of tappets T_1, which depress fuel pump suction valves and thus cut off supply of oil to engine cylinders. It should be noticed that lever A and levers B are interlocked so that first control levers B cannot be moved when A is in neutral position. Second lever A cannot be put from ahead to astern or vice versa if levers B are in any but no fuel position.

THE FIRST BRITISH INDIA DIESEL-ENGINED LINER.

The Engines of the "Domala." Constructed by the North British Diesel Engine Works Limited, Whiteinch, Glasgow.

The twin-screw motor passenger liner *Domala*, which was recently put in commission by the British India Steam Navigation Company, is the first of a number of large Diesel-engined ships building for that company on the Clyde. This vessel was built by Barclay, Curle & Co. Limited, Whiteinch, Glasgow, who have built a number of vessels of the same class, but fitted in some cases with reciprocating steam engines and in others with geared turbines. With the advent of the *Domala*, therefore, the owners will have every opportunity of judging the merits of the various types of machinery.

The most interesting feature of the *Domala* is naturally her machinery, which is entirely of British design and construction, the manufacturers, the North British Diesel Engine Works Limited, Glasgow, having entrusted the entire work of designing the machinery to their own technical staff. The builders are certainly to be congratulated on their achievement, as no other manufacturer of marine Diesel machinery has undertaken at the outset such a high-powered installation.

Main Engines.

The main engines are of the four-stroke cycle type, each engine having eight cylinders 26½ in. bore by 47 in. stroke, and developing normally 2,330 i.h.p. at 96 r.p.m.; the total indicated horse-power being therefore 4,660.

As may be seen from the plate drawings, the type of structure adopted in the North British Diesel design differs from that adopted by most other manufacturers. In fact, the method of construction appears to be quite novel. Long column bolts passing from the underside of the bedplate to the top of the entablature are provided to take the gas load, a light "A" frame being placed over each main bearing to steady the column bolts to relieve them of the lateral thrust due to the crosshead guide slipper.

The bedplate is of the usual box girder type arranged to sit on a plate and angle seat built up from the ship's inner bottom, light sheet iron oil trays being provided below the bedplate to collect the lubrication oil as it drains from the bearings.

The crankshaft is of the built type throughout, the proportions being designed to satisfy Lloyd's Register and Board of Trade requirements.

The cylinder construction presents no very unusual features, except that each outer cylinder is cast independently. The cylinder liners are of special Muirhead metal made by William Muirhead Limited, Shettleston.

The cylinder covers, it will be noticed, are of unusual design, the inner face being recessed back to facilitate expansion. Pockets are provided fore and aft for the inlet and exhaust valves, enabling them to be placed wide apart so that water passages may be provided between them and the fuel valve.

Reversing Gear.

Perhaps the most novel feature of the engine is its reversing gear. Duplicate cams for ahead and astern running are provided side by side on a common camshaft; and in order to change from ahead to astern or *vice versa*, the camshaft is first lowered bodily until the cams are clear of the rollers, then moved longitudinally to bring the alternate set of cams beneath the rollers, and finally raised into its working position again. The lowering and raising of the camshaft is achieved in a very ingenious way. The camshaft bearings, as may be seen from the drawings, are provided with an extension or arm which is rigidly pivoted to the engine structure. The under sides of the bearing blocks rest each on an eccentric keyed on the layshaft immediately below the camshaft. It will be seen that when the layshaft is caused to rotate through its full travel, which is one revolution, the camshaft bearings, which rest on the eccentrics, will first be lowered and then raised. This gear, which forms the subject matter of a patent, has been found to operate very reliably under the most arduous conditions.

A direct acting air-operated reversing engine by McTaggart Scott & Co. Limited revolves the layshaft by means of a rack and pinion. It also operates the scroll gear for moving the camshaft longitudinally.

The usual four valves are provided in the cylinder cover for starting, inlet, fuel and exhaust. The fuel valves are designed to open outwards so that the spindles may be withdrawn readily for inspection. The exhaust valve cages are water cooled, and the valves themselves provided with special cast-iron renewable faces.

Short tappet rods and rocking levers are provided for transmitting the cam motion to the valves. A roller guide is provided on each tappet rod immediately above the cam rollers to prevent lateral movement of the rods.

Camshaft Driving Gear.

The camshaft driving gear is also of a novel character. As may be seen from a section of the engine, a spur wheel mounted on the mid crankshaft coupling drives another spur wheel of twice the diameter provided on the short intermediate shaft. This intermediate shaft also carries one of the lower pair of skew gear wheels, the other pair being placed at the camshaft and upper end of the vertical shaft. The attraction of this design is that, by interposing the spur wheels at the crankshaft end of the gear, the danger of the timing of the valves being disturbed by end movement of the crankshaft is eliminated. Moreover, the skew gears, which are more subject to wear, are all of a pattern, and run at half the engine speed.

The hand-operating gear for starting and fuel regulation is arranged on the "block" system, separate controls being provided for the forward and aft groups of four cylinders. This system enables the engine to be changed from starting air to fuel with greater certainty.

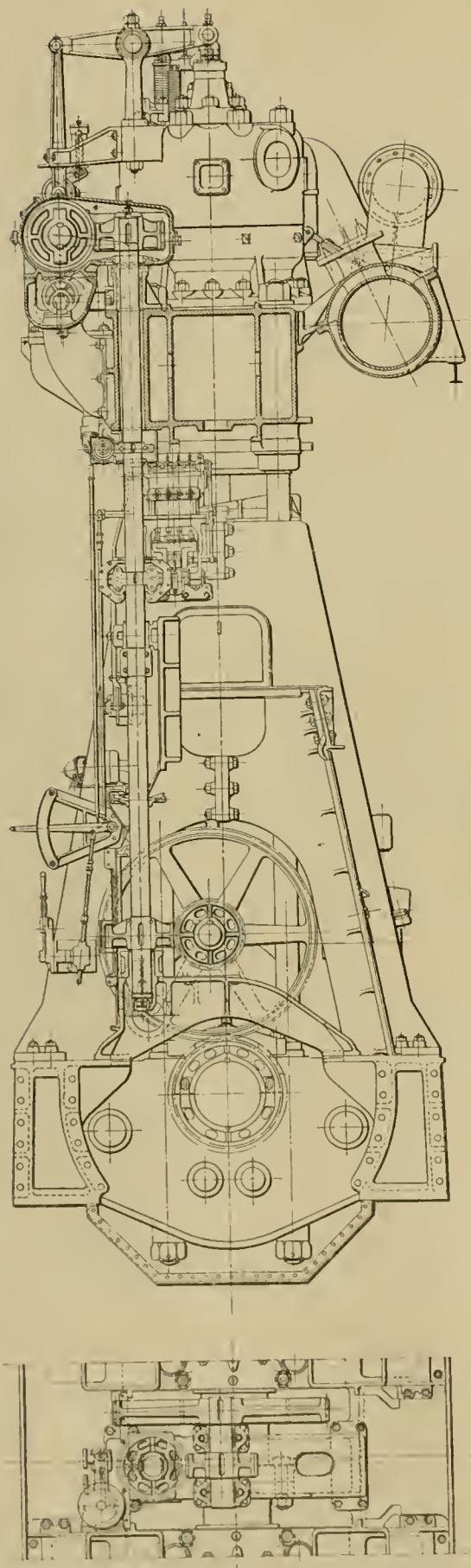
Separate fuel pumps are provided for each cylinder, a practice which is now almost universal. In this design the pump spindle stuffing-boxes have been dispensed with, and close-fitting cast-iron sleeves fitted in their stead.

An Aspinal governor is provided on each engine as a safeguard against excessive speed. The governor acts on the fuel pump suction valves.

Motor turning gear is provided for each engine of the double reduction worm type, and operates on teeth provided on the periphery of the flywheel.

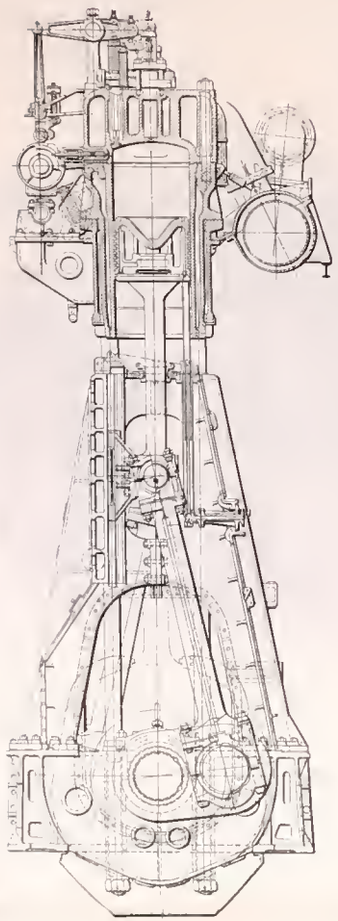
Auxiliaries.

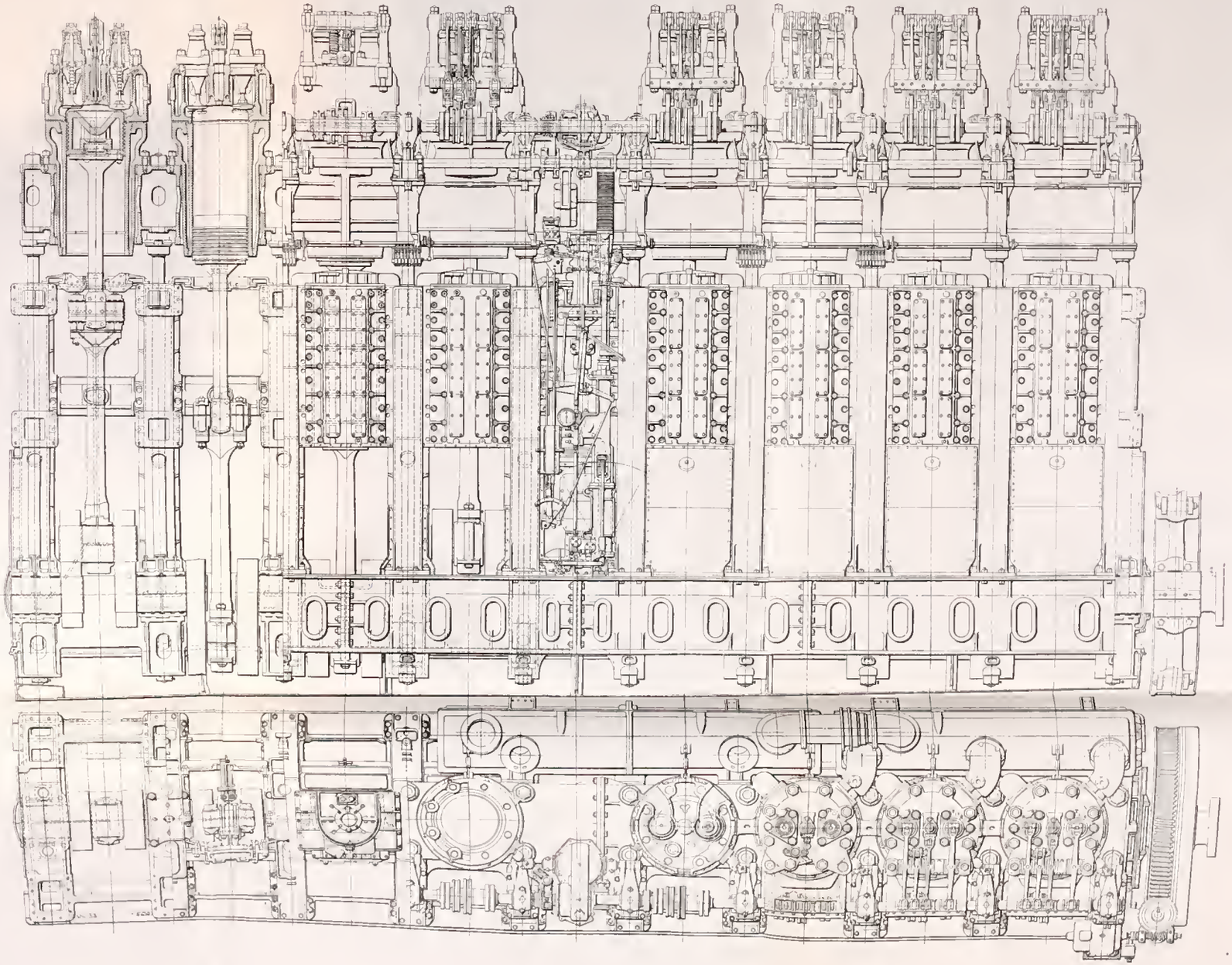
In addition to the two main engines, the *Domala* has two main compressor Diesel engines. These latter are directly coupled to two three-crank three-stage compressors of the Weir-Murray Workman type, one compressor supplying sufficient injection air for its own Diesel engine plus the two main engines, the other acting as standby. The *Domala* is 500 h.p. more powerful than the three later Diesel-engined ships of her class or size. This extra 500 h.p. was obtained without any alteration to the main Diesel engines by making the injection compressors independent on the *Domala* only, so that the main Diesel engines for all four vessels are similar.

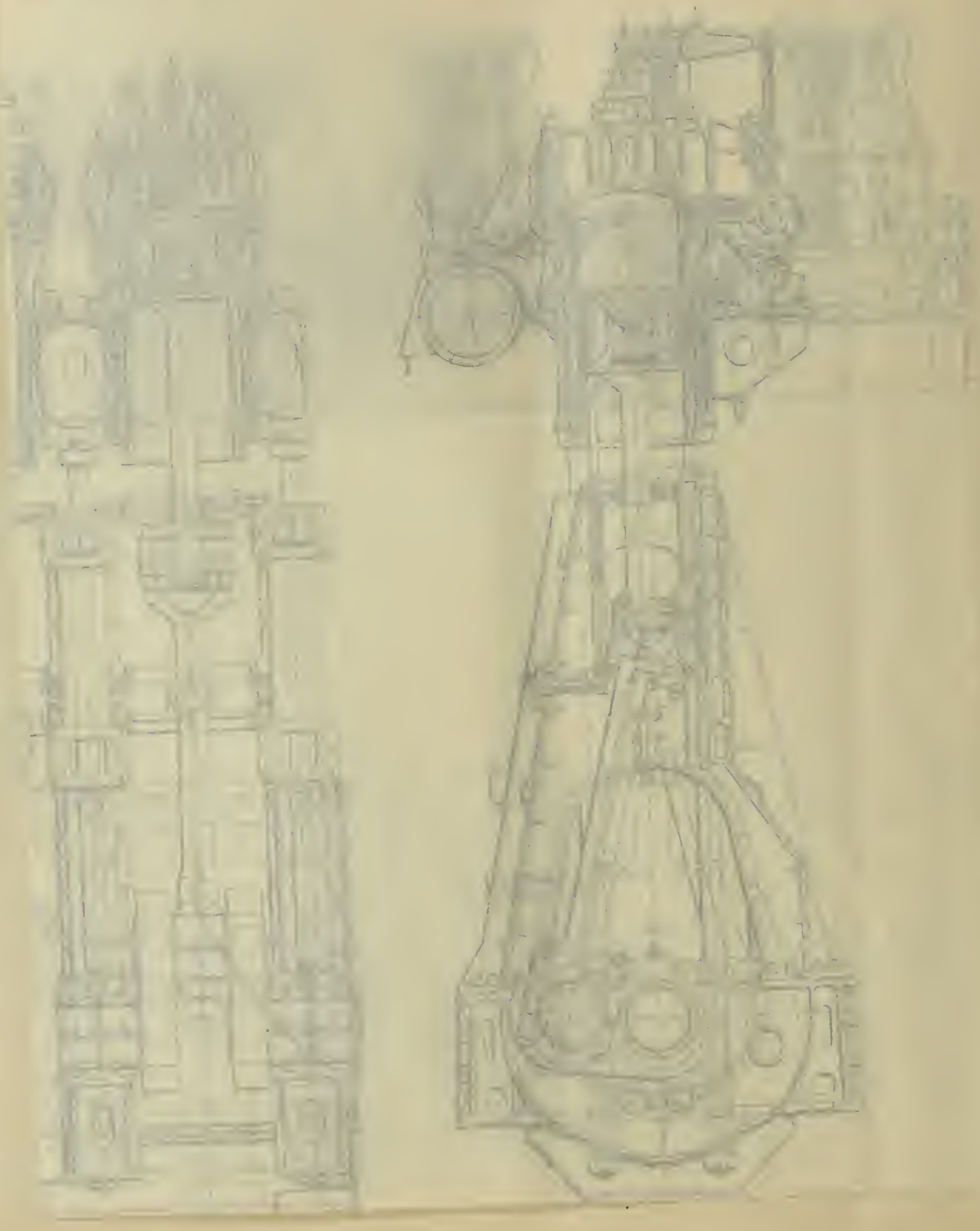


M.S. "Domala." End Elevations of Main Engines, showing Gears for Operating Camshaft, and Cylinder Supports.

MAIN ENGINES OF M.S. "DOMALA." TWO SETS, EACH DEVELOPING 2,330 I.H.P. AT 96 R.P.M., DESIGNED AND CONSTRUCTED BY THE NORTH BRITISH DIESEL ENGINE WORKS LIMITED, WHITEINCH, FOR THE FIRST DIESEL-ENGINED BRITISH INDIA LINER.







A small steam compressor is provided for emergency purposes.

Forced lubrication and salt-water cooling are adopted throughout for both main and auxiliary engines.

The *Domala* is fitted throughout with electrically operated deck machinery and electrically driven engine room auxiliaries. For this duty two Diesel driven generators are provided, each having a maximum output of 215 kw. at 220 volts.

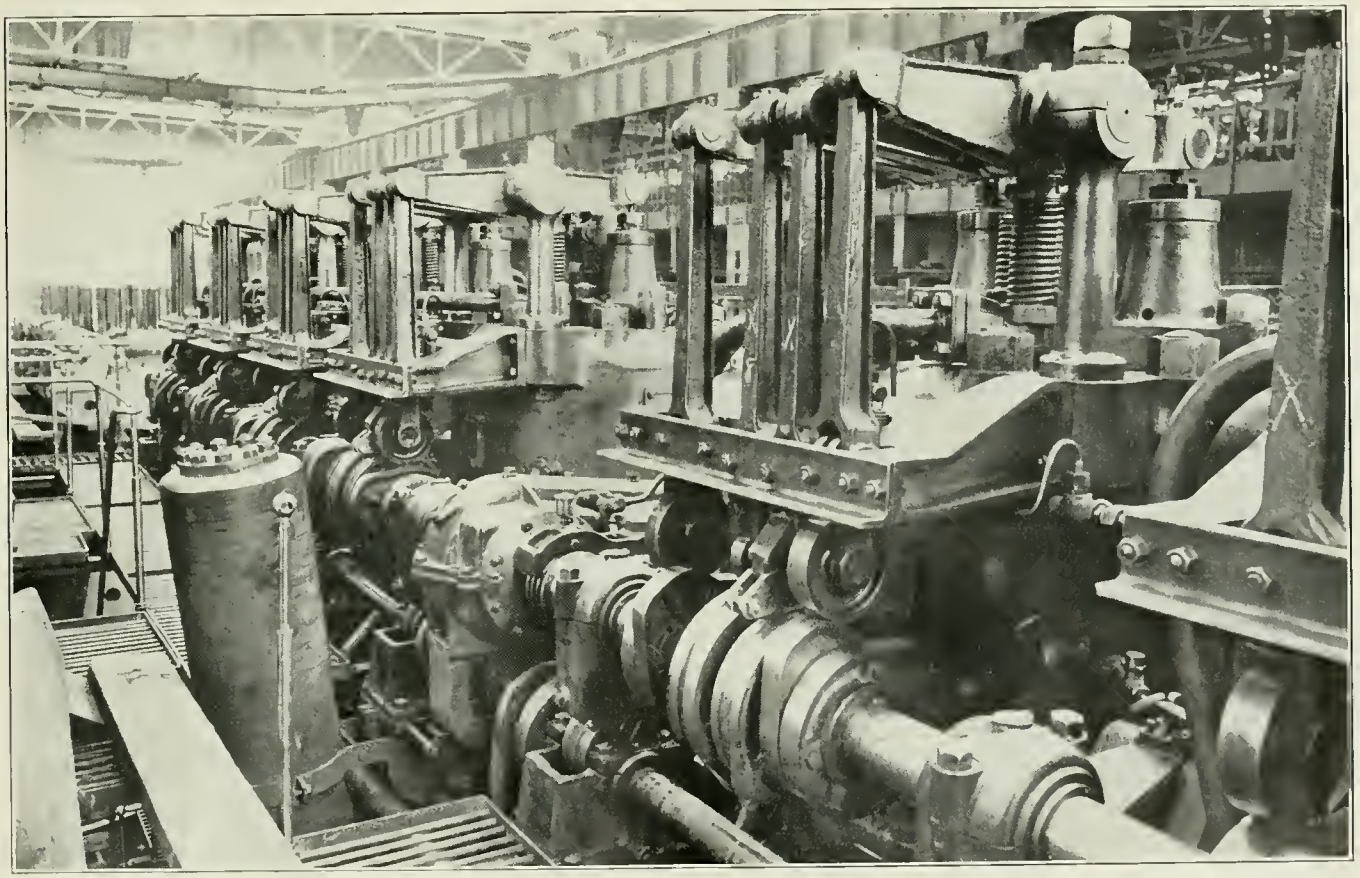
In addition, a small 55 kw. generator is provided directly coupled to a two-cylinder hot bulb engine. This latter plant is provided principally to take the load in port at such times as the deck machinery is out of operation.

A small vertical boiler is provided at the aft end of the engine room. This boiler, whish has a heating surface of 240 square ft., is of the "Blake" type, built by William Beardmore & Co. Limited, Dalmuir.

After exhaustive test bed trials, where the engines were coupled to a large reversible Heenan & Froude brake, the machinery was installed and the vessel taken down the Clyde to undergo her sea trial. The machinery behaved very satisfactorily, and the builders are naturally proud of the fact that full power and speed were easily attained on the first day of the trials. A number of runs were made on the measured mile at Skelmorlie, and subsequently a 48 hours' full power trial was carried out to comply with the owners' requirements. The speed during trials averaged 13½ knots and the fuel consumption of Anglo-Persian oil ·296 lb. per i.h.p. hour, a very creditable figure.

On the completion of the trials the vessel was taken over and proceeded to London.

The owners, the ship's engineers and also those responsible for her navigation expressed themselves as highly satisfied with her performance, and the ready response which her machinery made even to most abnormal calls from the bridge.



Cylinder Heads of one of the Main Engines of the "Domala," showing the Camshaft and Valve Levers.

THE "ISHERWOOD" SYSTEM.

Although the year 1921 has been very barren of orders for new ships, it is interesting to note that the "Isherwood" system has secured its share of the few new contracts that have been made, and so maintained the progress it has consistently made since it was introduced in 1907.

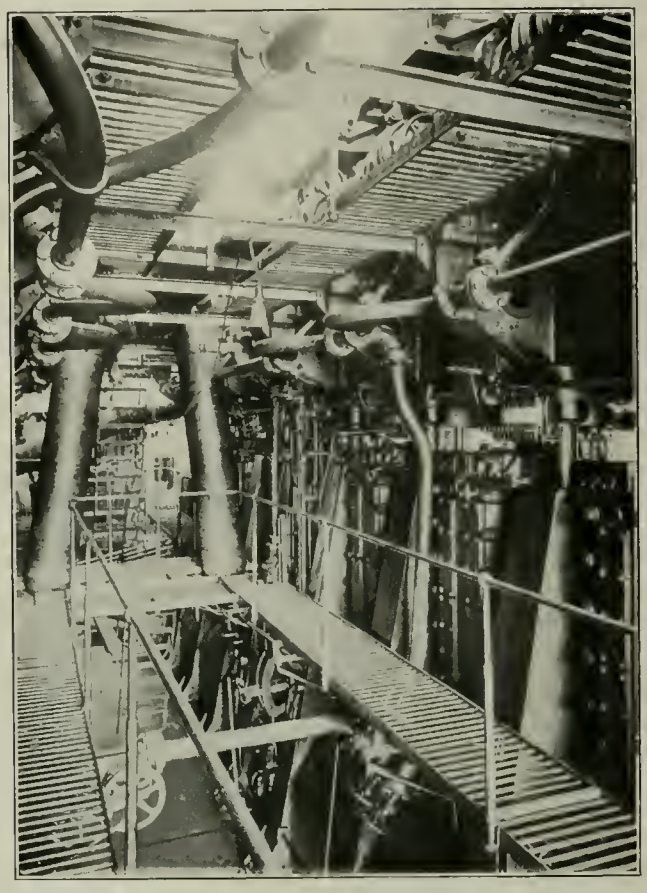
Of the most interesting ships among this year's contracts is a vessel ordered by the Japanese Navy Department for service in connection with the supply of oil fuel for the Japanese fleet. The vessel is over 500 ft. in length, and she is to be propelled by twin-screw engines with electric drive.

During the course of the year a number of oil tank steamers of over 18,000 tons d.w. have been launched. These vessels are the largest oil tankers which have yet been built.

The following table, which records the number of "Isherwood" ships contracted for year by year, is very interesting in that it shows the general ups and downs of shipbuilding from a world aspect over quite a number of years:—

Year.	Number of ships built, under construction and on order.	Deadweight carrying capacity.
		tons.
September, 1907, to December,	6	31,608
1908	36	212,992
1909	76	484,752
1910	140	958,795
1911	240	1,777,348
1912	270	1,993,031
1913	311	2,351,322
1914	468	3,548,221
1915	620	4,666,000
1916	800	6,332,150
1917	1,070	8,707,700
1918	1,260	10,594,700
1919	1,395	11,962,400
1920	1,118	12,032,400
1921		

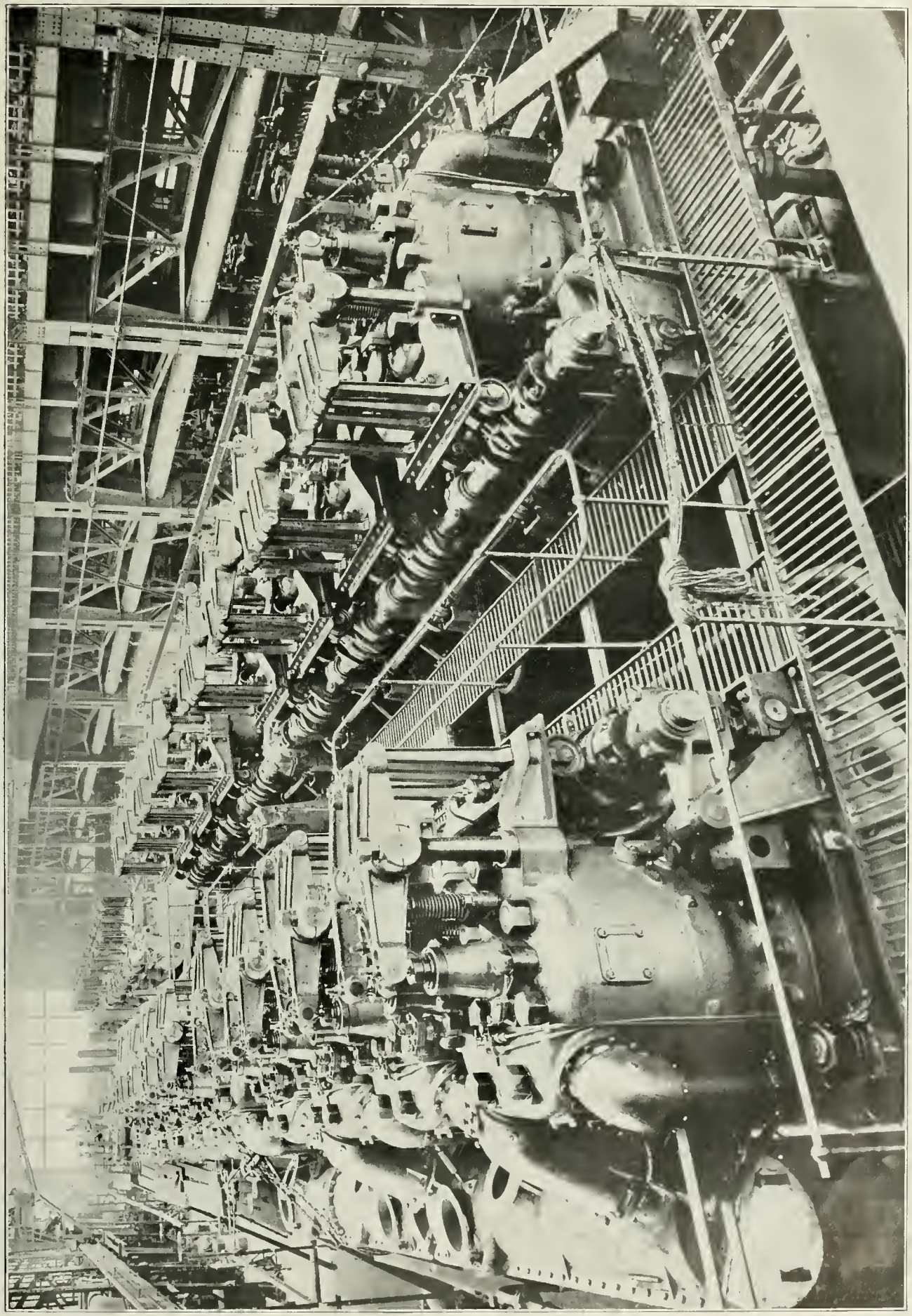
Putting one of the Diesel Engines on the "Domala."



Middle Platforms between the Main Engines showing Lubricating Gear.

Driving Platform between the Main Engines with Controls at Centre.

A Nearer View of the Controls of the "Domala" on one of the Main Engines.



Main Engines of the "Domala," Erected in the Shops of the North British Diesel Engine Works, Whiteinch, Glasgow. Another set of Engines in course of Erection is seen in the background.

A NEW ELECTRIC WINCH.

The Metropolitan-Vickers—Harfield Electrically-operated Ships' Winch.

The illustrations and drawing reproduced on this and the succeeding page show the new winch which the Metropolitan-Vickers Electrical Company, in conjunction with Harfield & Co., have recently developed. This is an electrically-operated ships' winch, which is claimed to be in advance of any other similar winch now on the market. Harfield & Co. are responsible for the mechanical portion and the Metropolitan-Vickers Company for the design and manufacture of the electrical equipment.

In designing this winch the chief point kept in mind was that of simplicity of operation, having regard to the fact that winches are usually operated by unskilled labour.

A 3-ton winch has been built and standardised, the general arrangement of which is shown on the drawing opposite. It will be noted that the winch comprises a main winding drum 16½ in. diameter by 2 ft. long, and two warping ends 14 in. diameter.

The winch is operated through worm gearing, the worm being of forged steel and the worm wheel of phosphor bronze, the worm being double thread and 1½ in. pitch. This gear operates in an oil bath which is totally enclosed.

The motor, which is series wound with shunt limiting winding, has been specially designed for the duty, it having been decided that it was not possible to adapt a commercial design of machine. The motor is of the water-tight type and is liberally rated.

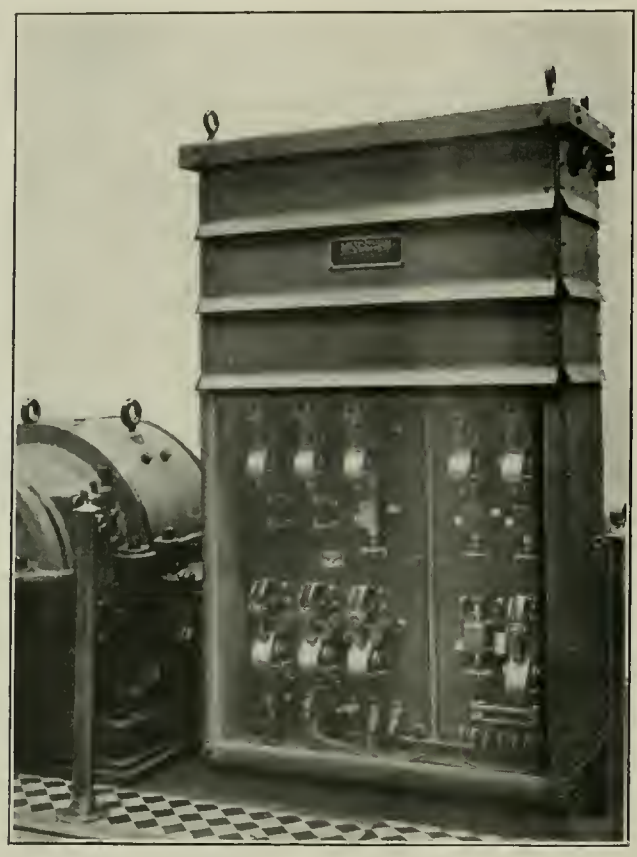
The full load speed of the motor is 520 r.p.m., at which speed the horse-power developed is 30, and the lifting speed of the winch 100 ft. per minute with a load of three tons. The maximum speed at which any load can be lowered is 200 ft. per minute.

Incorporated in the rear-end bracket of the motor is a centrifugal brake, the object of this being to prevent a dangerous speed being attained when lowering the load. As this brake is purely mechanical in action, it invariably acts at the speed for which it is set and is not affected in any way by the electrical conditions.

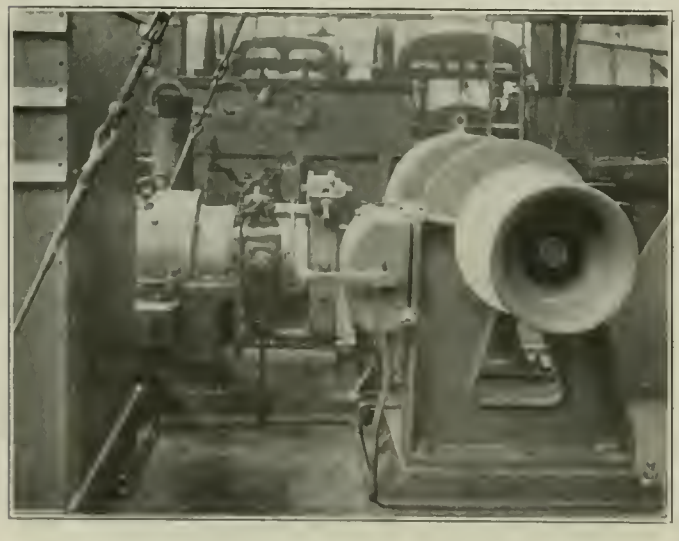
A slipping clutch is also fitted to prevent any damage being done by the stored energy in the motor armature in the event of the empty hook catching, say in the cargo hatchway, when hoisting, which is always liable to happen.

A solenoid brake is provided which is normally held by a spring in the "on" position, it being released as soon as the controller is moved into the running position. It will thus be seen that should the supply of current fail through any cause whatever, the brake is applied automatically.

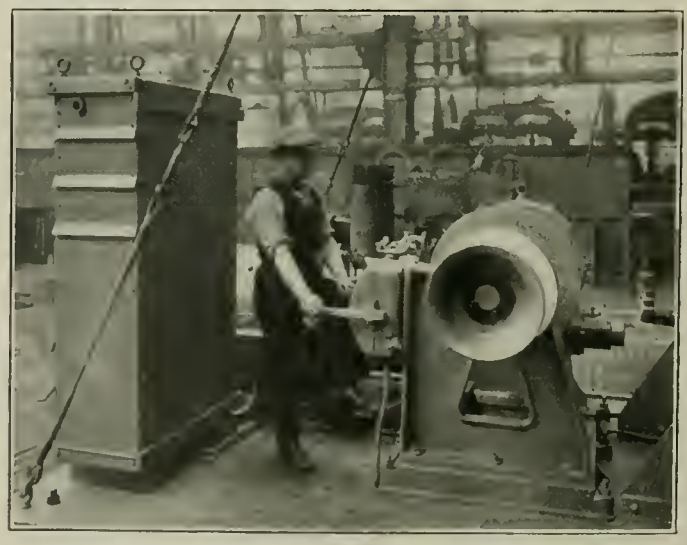
A foot brake is also provided, and this is interlocked with



Control Gear of the Winch.



The Metropolitan-Vickers—Harfield Electric Winch.

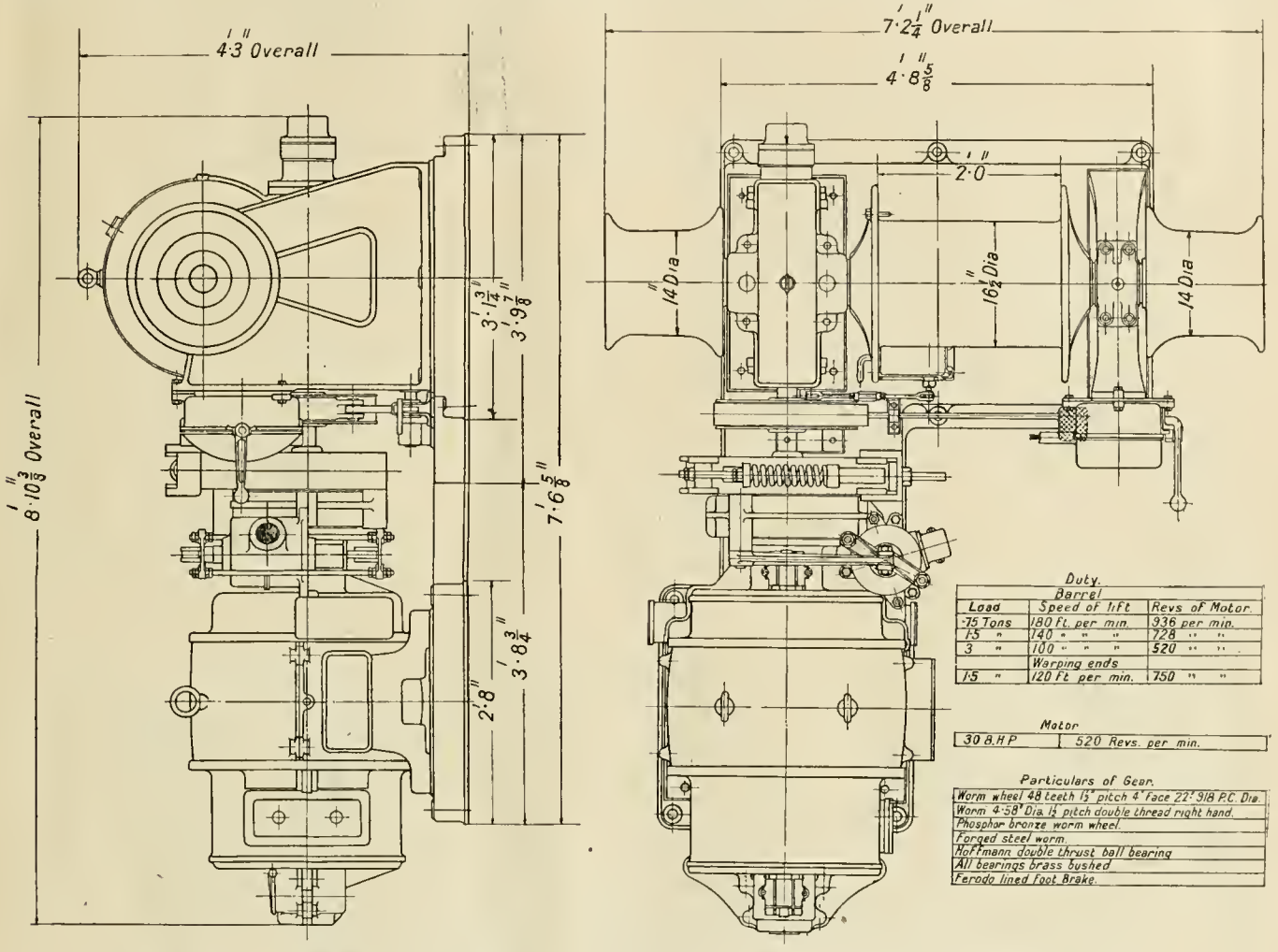


Hand and Foot Controls of the Electric Winch.

a switch for cutting out the motor, so that in the event of the foot brake being applied with the controller in the "on" position, current is cut off from the motor, but the solenoid brake is still held off. On releasing the foot brake, the controller still in the "on" position, the motor immediately starts up again, and automatically accelerates up to the speed corresponding with the controller position.

The control gear is of the contactor type, contained in a sheet steel case, and arranged for mounting below deck in any convenient position. A water-tight master controller is mounted on the winch in a convenient position, three speeds hoisting and lowering being provided for.

In addition to the winch described herewith, the company also make a simpler type, which is fitted with a foot brake, magnetic brake and a drum controller. This, of course, is much cheaper than the winch described above, and does not possess the same advantages. The company have also turned their attention to capstans and windlasses, and are now in a position to quote for any class of deck machinery.


4·3 Overall
8·10⅜ Overall
3·1¾
3·9⅞
7·6⅝
3·8¾
2·8
7·2¼ Overall
4·8⅝
2·0
14 Dia
16½ Dia
14 Dia
Duty.
Barrel
Load | Speed of lift | Revs of Motor
·75 Tons | 180 Ft. per min. | 936 per min.
1·5 " | 140 " " " | 728 " "
3 " | 100 " " " | 520 " "
Warping ends
1·5 " | 120 Ft. per min. | 750 " "
Motor
30 B.H.P | 520 Revs. per min.
Particulars of Gear.
Worm wheel 48 teeth 1⅝" pitch 4" face 22" 918 P.C. Dia.
Worm 4·58" Dia. ½ pitch double thread right hand.
Phosphor bronze worm wheel.
Forged steel worm.
Hoffmann double thrust ball bearing
All bearings brass bushed
Ferodo lined foot Brake.

General Arrangement of Metropolitan-Vickers—Harfield Standardised 3-Ton Electric Winch.

ENGAGEMENTS FOR FEBRUARY.

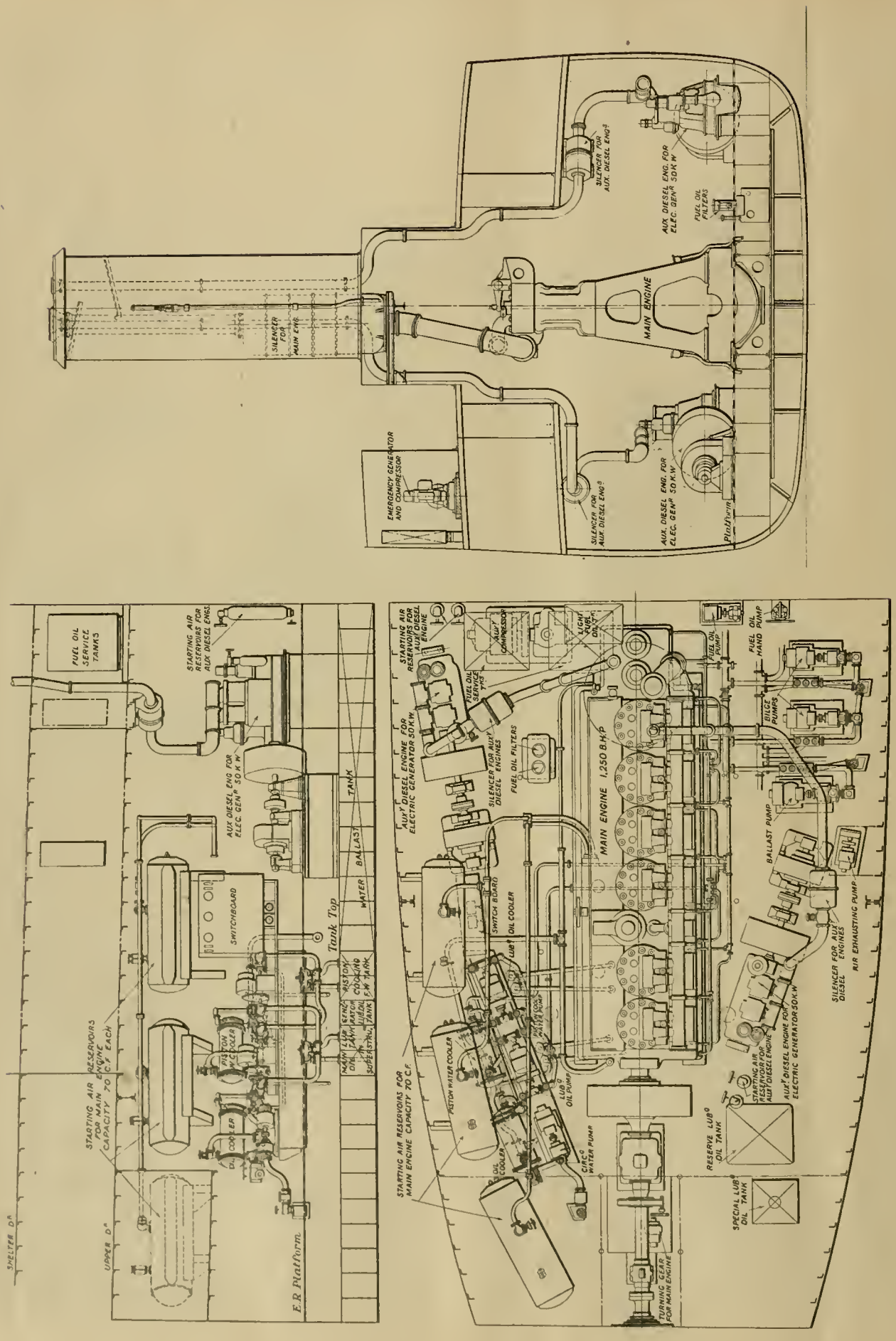
The Society of Engineers.—Monday, February 6, inaugural meeting in the apartments of the Geological Society, Burlington House, London, W., at 5 for 5.30 p.m. Presidential address by T. J. Gueritte, B.Sc. (Paris), M.Soc. Ing. Civ. de France, F.S.E.

Institute of Marine Engineers.—Meeting at the Institute, the Minories, Tower Hill, London, E., at 6.30 p.m.—Tuesday, February 7, "Combined Internal-Combustion and Compressed-Air Engine," by R. W. Robinson.—Tuesday, February 21, "Types of Large Marine Oil Engines," by D. R. Hutchison.—Tuesday, March 7, "The Trail in Mexico," by C. Williamson Milne. Lantern views. Ladies' night.

Greenock Association of Engineers and Shipbuilders.—Meeting in the Watt Memorial, Dalrymple Street, Greenock, at 7.45 p.m. Tuesday, February 7, "An Experimental Marine Still Engine," by David Hutchison (Scott's Shipbuilding and Engineering Co. Ltd).—Saturday, February 18, visit to Greenock Foundry; demonstration of Still engine in operation; meet at works' gate at 3 p.m.—Tuesday, February 21, "Notes in connection with the Electrical Equipment of Diesel-driven Vessels," by Alex. Gow, A.M.I.E.E.

North-East Coast Institution of Engineers and Shipbuilders.—Meeting in Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne, at 7.30 p.m. Friday, February 10, "Shipbuilding Methods," by John McGovern.—Friday, February 24, "Running Costs of Diesel-Engined Ships," by T. Madsen, of the Swedish Transatlantic Steamship Company.

Institution of Electrical Engineers.—Meeting at Savoy Place, Victoria Embankment, London, W.C., at 5.30 for 6 p.m. Thursday, February 16, "Rotary Converters, with special reference to Railway Electrification," by F. P. Whitaker.—Tuesday, February 21, Annual Dinner and Reunion at the Hotel Cecil, Strand, London, W.C., at 7 for 7.30 p.m.



General Arrangement of Machinery Space, M.S. "Pinzon," fitted with Beardmore-Tosi Marine Oil Engine, 1,250 b.h.p.

THE NEW MOTOR SHIP "PINZON."

First Vessel Fitted with Beardmore-Tosi Engines.

The m.s. *Pinzon*, which is the first vessel to be fitted with the Beardmore-Tosi type of marine Diesel engine, recently underwent a series of successful trials on the Clyde. In our January number a general description of this engine was given together with particulars of the test-bed trials. The engine is of the four-stroke cycle, single-acting, marine cross-head type having six cylinders of 720 mm. ($24\frac{7}{16}$ in.) with a stroke of 975 mm. ($38\frac{3}{8}$), and at 120 r.p.m. develops 1,250 b.h.p., 1,620 Diesel i.h.p. equivalent to 1,500 steam engine i.h.p., and gave the vessel a speed of over 12 knots on trial.

The *Pinzon*, built by William Beardmore & Co., Dalmuir, has the following dimensions: 240 ft. length, 38 ft. beam, 18 ft. depth, 2,050 tons deadweight. The installation does not include a boiler, a condition which is very desirable in vessels for the fruit-carrying trade, for which the *Pinzon* has been specially designed for the owners, MacAndrews & Co. Limited, London. All the auxiliary machinery, such as winches, windlasses, steering gear, &c., are electrically driven. The engines are installed right aft, giving the vessel five spacious holds. The officers and crew are provided with fine quarters; these, together with roomy holds, have been made possible by the saving in machinery and bunker space consequent on fitting Diesel machinery.

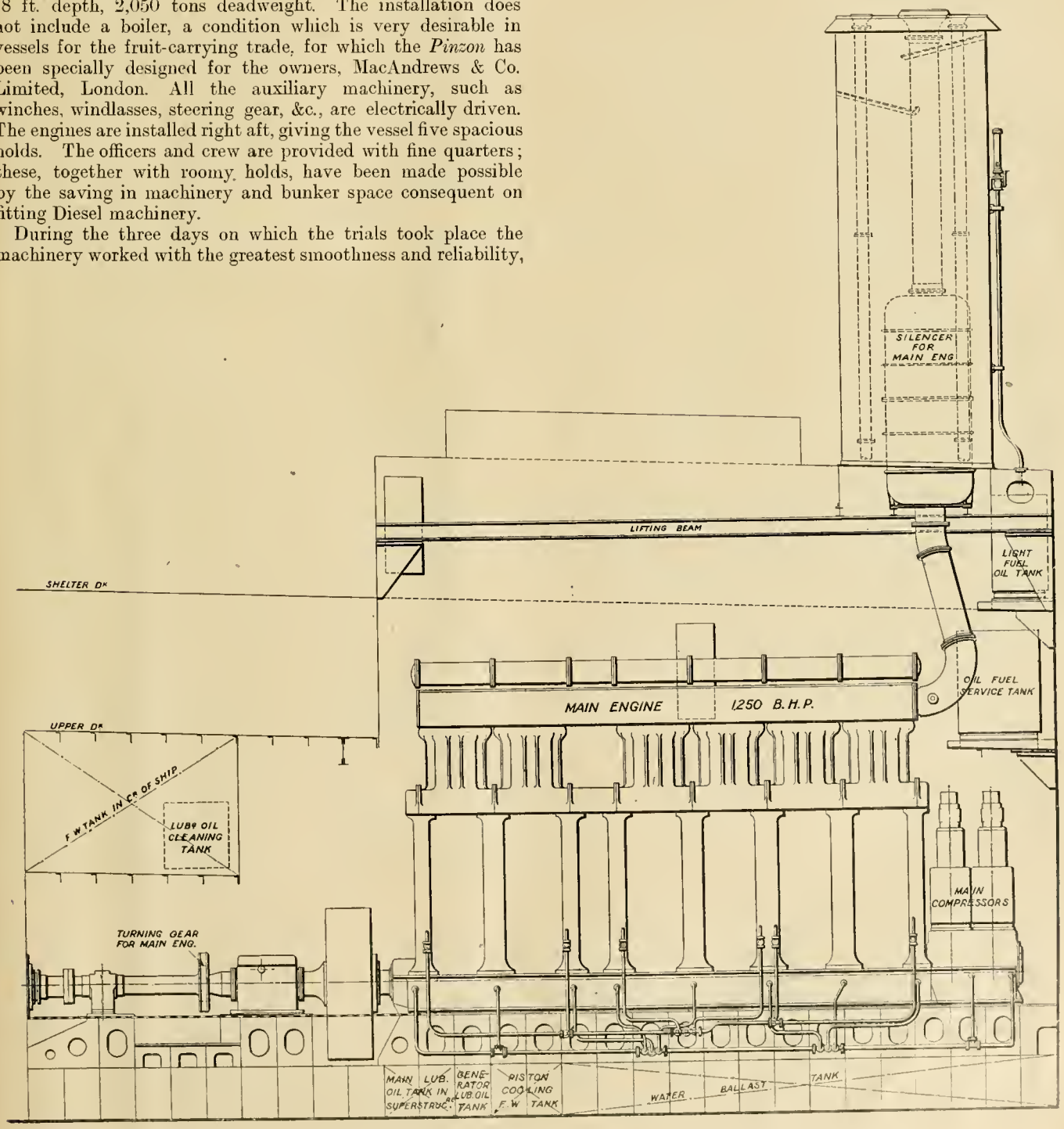
During the three days on which the trials took place the machinery worked with the greatest smoothness and reliability, the owners and builders being highly satisfied with the results. With the vessel fully laden, the revolutions per minute of the engines for 9, 10 and 11 knots were 95, 105 and 115 respectively. Particulars of the fuel consumption form very interesting reading and are given below:—

DATA OF FUEL CONSUMPTION.

All purposes:—

(*a*)	Tons per day	3	4	5·2
(*b*)	Cost of fuel per hour (at £4 per ton)	10/-	13/4	17/4
(*c*)	Cost of fuel per day (24 hours)	£12	£16	£20·8
(*d*)	Cost of fuel per 1,000 ton miles	6½d.	7¾d.	9¼d.

NOTE.—The cost of lubricating oil for all purposes averages one-sixteenth of the fuel cost.



Side Elevation of Machinery Space, M.S. "Pinzon," showing Profile of Main Engine.

DRILL TESTS OF MARINE BOILERS.—II.

Special Cases—Water-Tube Boilers—Cutting Out Tubes—Subsequent Water and Steam Pressure Tests.

In the last article (page 12) a few special cases presenting difficulties in the removal and replacement of tubes were mentioned. In the Babcock & Wilcox boilers a bottom tube can be removed by cutting a groove in each end with a cross-cut chisel, and removing the tube by means of a drawbar; or by cutting round each end of the tube with an internal cutter, and removing the end pieces by cutting through with a cross-cut chisel. To remove an upper tube, close the ends with a cupping and drawing tool at the same time driving the tube out. There is no need to cut the tube in any way.

With the Niclaussée boiler, a special apparatus is necessary, and is operated as follows. The bridge is placed against the header and the spindle is screwed into the place of the head of the inner tube. The nut is then tightened, and, as soon as it begins to bear against the bridge the tube should move outwards. The apparatus is then removed. A pole is then passed into the tube, well to the end, and bears the weight of the tube while it is being pulled out. Immediately an outer tube is removed the turned surfaces of tube and header must be cleaned and smeared with grease. To replace the tube, coat the coned faces with mineral grease, and push into place with a special pole, making sure that the marks which denote the position of the waterways are kept in a vertical line. Tap the tubes home with a lead hammer, put the dogs on, and moderately tighten nuts. No great force must be used to make the joints tight.

As mentioned in the previous article, boilers fitted with D or non-circular tower water drums, which have seen four years' service, or which show signs of cracks or grooving in the vicinity of, or at the longitudinal seams of, the tube and wrapper plates, must have "cores" taken. These cores are taken by means of trepanning tools. After cutting the cores they are buffed, and should the buffing show a crack in the plate, extra cores must be taken to ascertain the length of the crack. A typical trepanning record is shown in Fig. 5. The position and extent of pitting and grooving in the longitudinal seams of the lower pockets are shown in this diagram. Marks thus ⊕ denote $\frac{1}{64}$ in. depth of pit, and mark | denotes $\frac{1}{64}$ in. depth of groove. The width of the pit or groove is shown by dimensions at side. The parts trepanned are shown thus, ⊕. Caulking marks adjacent to edge of tube plate are shown by brackets. All lengths taken are from the edge of flange of front end plate. The tabulated result forms a concise and ready record of the operation. During the war many ships of the Royal Navy, especially the smaller craft, were laid up owing to wrapper plate trouble. The circular water drum, which has lately been introduced, will, of course, do away with this defect; but it must be borne in mind that the circular drum is expensive, owing to the machining of the inner surface where the tube ends project.

DETAILS OF CORES

Boiler Core No	Side	Present Thickness	Depth of Crack	Original Thickness	Metal Left	Combined Wastage & Crack
B.8 762	Left Hand Fire	32	4	32	28	4
B.8 766	Left Hand Wing	32	2	32	30	2
B.8 753	Right Hand Fire	32	4	32	28	4
B.8 754	Right Hand Fire	32	5	32	27	5
B.8 758	Right Hand Wing	32	5	32	27	5
			64ths of an inch			

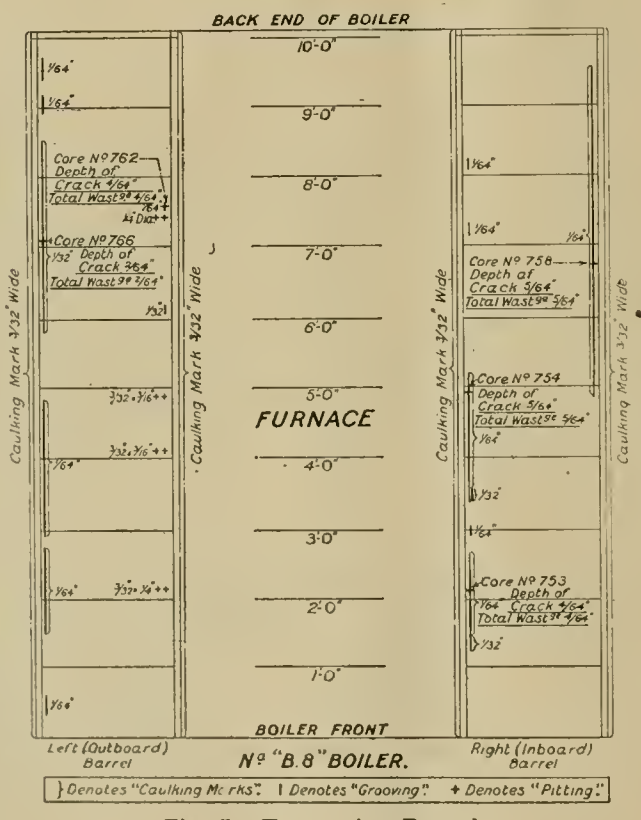


Fig. 5.—Trepanning Record.

Cutting Out Tubes for Test.

As regards the tubes cut out for test, an expanded view of the steam reservoir tube plate is shown in Fig. 6. As will be seen, the tube rows are lettered, and in the test record the row is given and the number in from the front of the boiler. In the case under consideration, a whole row is cut out from the port side, from fire row to outside row, shown by double lines. From the starboard side four tubes are cut out, also shown by double lines. The large tubes are to be drilled for thickness, the selected positions being such as will give a good general estimate. Fig. 7 shows the position of holes drilled in steam drum, water reservoirs, and downcomer tubes. Holes A, B, C, D are drilled in the downcomer and J in the bend. E is drilled in steam space at top, F at waterline, G in water space in back end plate, and H, I in lower water reservoirs. If considered necessary, a hole may be drilled in front end plate at K. Drill testing Belleville and large straight-tube boilers is a simple matter, but at each test a diagram must be prepared showing all tubes drawn or cut out, and all holes drilled. At the conclusion of the drill test a report is made out with all detailed information as to durability of reservoirs, generating tubes, economiser tubes (when fitted), permanent tube connection boiler casings, supports, uptakes, furnace fittings and funnels. In small tube boilers the clearance for the expansion of

the feet must be verified, and also that it is in the right direction.

Fig. 8 shows the Cochrane type of vertical boiler, of which a great number are fitted as deck auxiliary, or donkey boilers. In this case the tubes which should be drawn and cut are denoted by ⊕. Holes A, B, C, D, E, F are drilled, and if considered necessary, G. With this type of boiler, re-tubing is a simple and inexpensive operation, and should there be any doubt as to the durability of the tubes, on cutting up and examining, the generator should be re-tubed.

The specimen boilers dealt with should be sufficient to show how a reliable test may be made of any type of fire-tube boiler. With fire-tube boilers or "tank" boilers, as they are sometimes termed, it is sometimes found that the studs securing the flanges of the boiler mountings have deteriorated. Such studs must be drawn or drilled out. Should the thread in the boiler shell be worn, the hole must be drilled to clear the old thread, re-tapped, and a bottle stud fitted. The boiler bearings and smoke-box doors must be examined, the automatic self-closing ash-pit doors also being examined as to their efficiency. In ships fitted with steam bakeries and cookers, these should be drill tested for wear and waste at the same time as the main and auxiliary boilers.

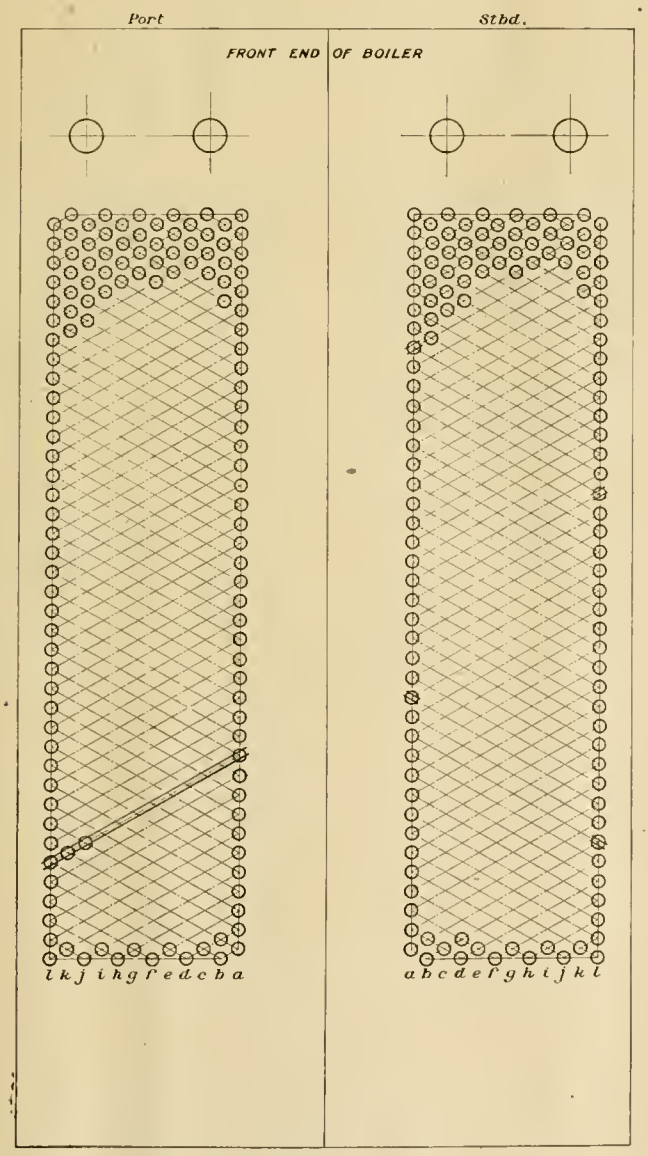


Fig. 6.—Cutting Out Tubes for Test.

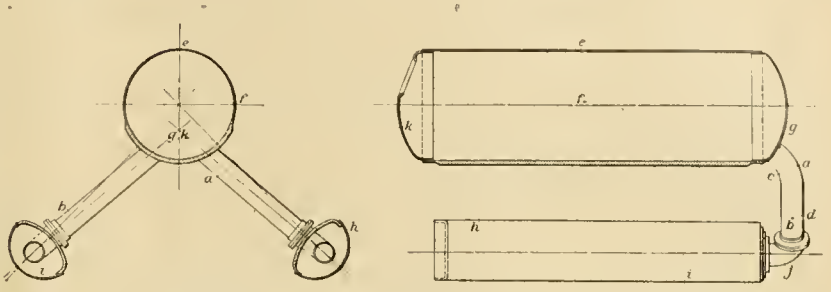


Fig. 7.—Position of Holes drilled in Steam Drum, Water Reservoirs and Downcomer Tubes.

Water-Pressure Test of Boilers.

On completion of the drill test, the boilers which have been under test should be thoroughly cleaned internally, great care being taken that all particles of metal left over from the drilling are removed. A water-pressure test is then applied. If a hand pump is not available for the test, a steam pump may be employed; but in such case all connections between the boiler under test and any pipe containing steam are to be isolated by means of blank flanges. The safety valves should be screwed down, and if the boiler stop valves will not stand the pressure, the following procedure may be adopted. Break the cover joints and insert over the valve spigot a piece of ¼-in. sheet rubber. Replace the cover, and screw down valve moderately tight; too much pressure will cut the rubber. As regards the load to be applied, the Admiralty practice is as follows:—When the load on the safety valve is 90 lb. per square inch or less, the test pressure is to be double the load. When the load on the safety valve is 90 lb. and less than 180 lb., the water pressure is to be 90 lb. per square inch greater than the load. Where the load is 180 lb. and above, the test pressure is to be 50 per cent. above the load. When testing

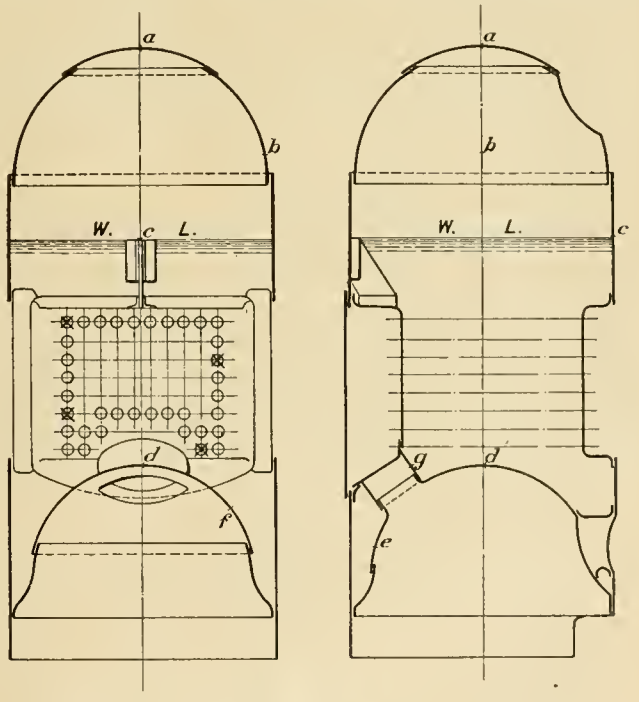


Fig. 8.—Drill Test Holes of a Cochrane Type of Vertical Boiler.

(*Continued on page* 88.)

PROPELLERS FOR OIL-ENGINED SHIPS.—II.

Analysis from Taylor's Curves—Pitches and Slips—Wake Values—The Thrust Horse-Power Basis.

In the previous article an attempt was made to analyse the results of the trials of the twin-screw motor ship *Suecia*, the single-screw motor ship *Eavestone*, and the single-screw steamer *Prinsessan Ingeborg*. This was doue by using Froude's thrust formula as the basis of analysis.

The results thus obtained were compared with those given by Mr. Blache, of Burmeister and Wain, and very different figures were arrived at in the two methods of computation. Mr. Blache used Taylor's propeller curves in his "Speed and power of ships" for design in conjunction with Professor McDermott's formula for wake. The present writer has made an analysis from Taylor's curves and finds some corroboration for the rather remarkable figures given in the previous article.

Analysis from Taylor's Curves. (Speed and Power of Ships, 1910.)

Take the case of the *Suecia*. Her propellers were 10 ft. in diameter and 8·16 ft. pitch. The number of blades has been assumed to be three on each screw; 0·5 disc area ratio (assumed).

In the $\rho\ \hat{c}$ diagram (Fig. 213), "Speed and power of ships," Taylor gives the results of experiments with standard elliptical propellers, 3-bladed; 0·3 mean width ratio; 0·04 blade thickness fraction; corresponding disc area ratio 0·483, which particulars are probably near those of the *Suecia's* propellers.

Taylor's formula is as follows:—

where P = power absorbed by screw
R = revolutions per minute
V_1 = speed corrected for wake.

$$\rho = \frac{RP^{\frac{1}{2}}}{V_1^{\frac{5}{2}}} \quad : \quad \hat{c} = \frac{DR^{\frac{2}{3}}}{PV_1^{\frac{1}{3}}}$$

Considerations of ρ are sufficient to guide in the present analysis. The *Suecia*, at 11 knots speed, developed 2,140 i.h.p. at 149 r.p.m. The pitch ratio of the propellers = 0·816; Vp or speed of propeller in knots = $\frac{\text{Pitch} \times \text{Revs.}}{101\cdot3} = \frac{8\cdot16 \times 149}{101\cdot3} = 12.$

The method of procedure is as follows:—

(*a*) The ρ values at given slip ratios for the given pitch ratio are noted.

(*b*) The corrected speeds proper to these slip ratios are found: $V_1 = Vp\ (1 - s)$.

(*c*) Speeds corrected to the $\frac{5}{2}$ power are tabulated.

(*d*) Knowing $P\ V_1^{\frac{5}{2}}$ and R, find $P^{\frac{1}{2}}$.

(*e*) Tabulate corresponding P—power absorbed—or S.H.P.

(*f*) Tabulate efficiencies proper to these slip ratios—"*e*."

(*g*) Find thrust horse-power. T.H.P. = S.H.P. × "*e*."

(*h*) Tabulate thrust in tons = $\frac{\text{T.H.P.} \times 0\cdot1455}{V_1}$.

On plotting these values of T on a base of real slip it is found that the required T is given at 50 per cent. slip. V_1 or speed corrected for wake becomes therefore $(12 \times 0\cdot5) = 6$ knots; the wake fraction becoming $\frac{11 - 6}{6} = 0\cdot83$.

(In the former article it was shown that the thrust necessary to overcome the augmented resistance was 10·75 tons. The modifications to real slip and to wake, assuming different values of thrust deduction, will be discussed later.)

Face and Effective Pitches and Slips.

Before proceeding further with the analysis it is necessary to make one or two corrections if a true comparison is to be made between this analysis and that from Froude's curves. Froude adopted zero thrust as zero slip: Taylor adopted zero slip as the point at which (face pitch × revs.) exactly equalled the speed of advance. A positive thrust is given at this point, which indicates that the face pitch of the screw is not the complete pitch. It will be seen that zero thrust is at a negative slip of 13 per cent. (see Fig. 5). Assume the number of revolutions at zero slip (face pitch) to be 100, then from the formula $\frac{R - Ro}{R}$ = slip, revs. of zero thrust become 88·5.

To bring the slips tabulated above into harmony with Froude's results treat the latter number of revs. as Ro and calculate the new slip ratios. This is as follows:—

On Taylor's basis Ro = 100.				On Froude's basis Ro = 88·5.	
Slip.	Revs.	Efficiency.		Slip.	Thrust in Tons (see above).
0	100	·54	$\frac{100-88\cdot5}{100}$	11·5	2·22
10	111	·62	$\frac{111-88\cdot5}{111}$	20·1	3·92
20	125	·635	$\frac{125-88\cdot5}{125}$	29·2	5·78
30	143	·595	$\frac{143-88\cdot5}{143}$	38·1	7·30

Real Slip.	ρ	$V_1 = Vp(1-s)$	$V_1^{\frac{5}{2}}$	$P^{\frac{1}{2}} = \frac{\rho V^{\frac{5}{2}}}{R}$	P = S.H.P.	"e" efficiency of screw.	T.H.P. = P × "e"	T = Thrust in tons.
0	5·5	12	499	18·4	339	·54	183	2·22
10	8·4	10·8	384	21·65	470	·62	291	3·92
20	12·8	9·6	285	24·45	600	·635	381	5·78
30	19·4	8·4	205	26·7	710	·595	422	7·30

It will be seen that the thrust given at 30 per cent. real slip (on the zero slip = zero thrust basis) is about 5·9 tons, which compares very closely with the 6·06 tons given in the previous article computed from Froude's formula. This agreement is so far satisfactory.

It remains to estimate the corresponding real slip at the point where the requisite thrust is being given. On the face pitch (Taylor's) this was found to be 50 per cent.; the corresponding slip on Froude's basis being 56 per cent.

Effect of taking Effective Pitch into Consideration.

The speed of advance being constant and the Ro in Froude's method being 0·885 of Taylor's Ro, Froude's effective pitch must be $\frac{\text{face pitch}}{0\cdot885}$. This value is in excess of that suggested by Froude as being suitable in trial analysis. Let it be assumed that this correction should come into the problem and try the *Suecia* on this basis. Then pitch becomes $\frac{8\cdot16}{0\cdot885}$ ft.

Four separate results have been arrived at in the foregoing analysis; these have been obtained by the following methods:

(*a*) By using Froude's thrust formula: face pitch: zero slip = zero thrust.

(*b*) From Taylor's $\rho\delta$ diagram: face pitch: zero slip = P × R = speed of advance (Fig. 5).

(*c*) From Taylor's $\rho\delta$ diagram: effective pitch: zero slip = zero thrust (Fig. 5).

(*d*) By using Froude's thrust formula: effective pitch: zero slip = zero thrust.

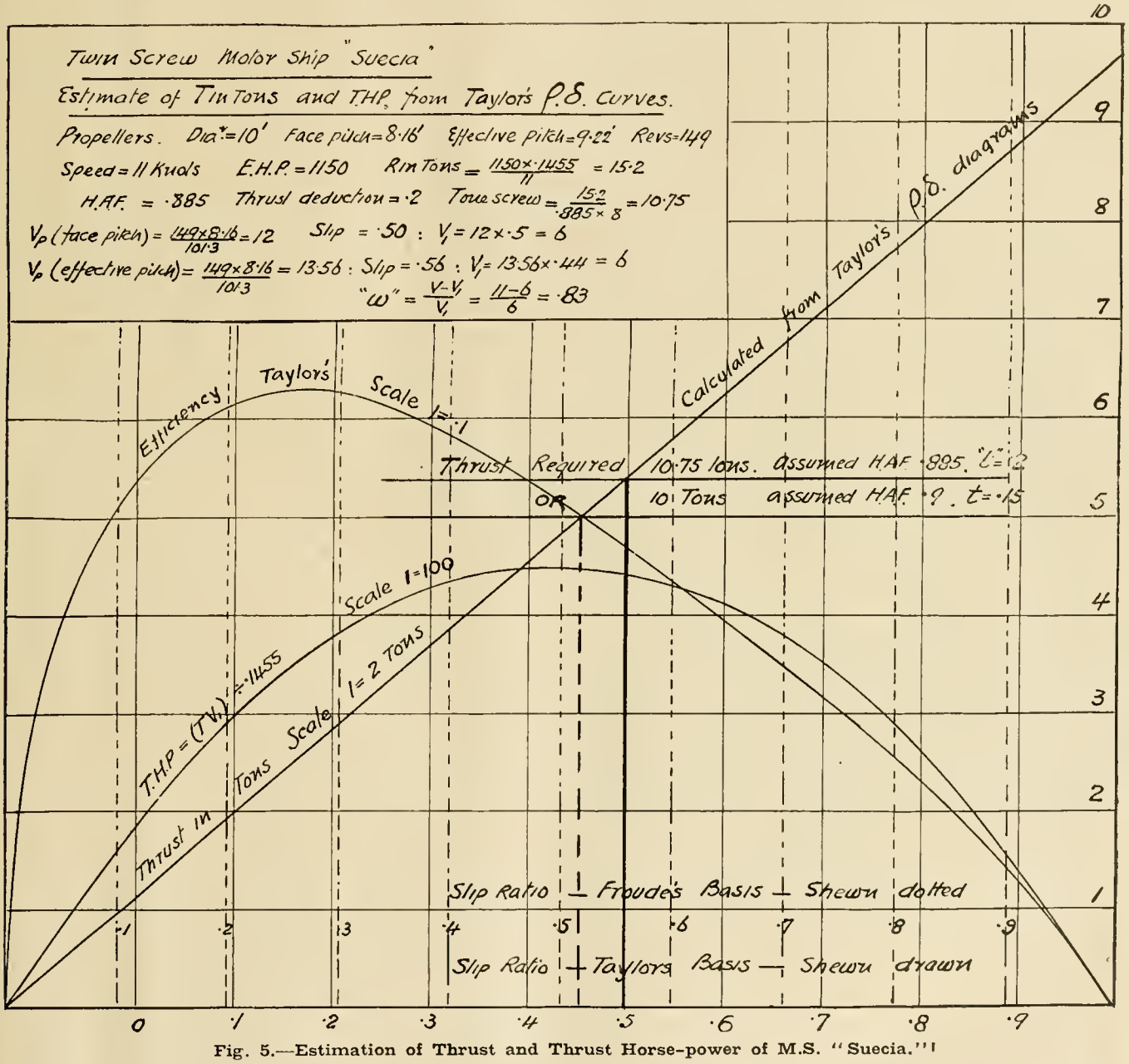


Fig. 5.—Estimation of Thrust and Thrust Horse-power of M.S. "Suecia."

= 9·2 ft.; and $Vp = \frac{9\cdot2 \times 149}{101\cdot3} = 13\cdot35$. Then $D^2V^2p\left(\frac{p+21}{p}\right)$ becomes $100 \times 178\cdot5 \times \frac{21\cdot92}{0\cdot92} = 426{,}000$. This, divided by basis case, $= \frac{426{,}000}{220{,}000} = 1\cdot93$, and thrust in tons at 30 per cent. slip = 1·93 × 3·46 = 6·7. The real slip at which the requisite thrust is given is 48 per cent.; the corresponding $V_1 = 13\cdot35 \times 0\cdot52 = 6\cdot95$: the resultant wake or "*w*" $\frac{11-6\cdot95}{6\cdot95} = 0\cdot58$.

The results are as under:—

Case.	Slip at 10·75 tons thrust.	V_1.	"*w*."
(*a*)	·53	5·64	·95
(*b*)	·50	6·0	·83
(*c*)	·56	6·0	·83
(*d*)	·48	6·95	·58

As the result of the above analysis the writer concludes that an amendment to the method adopted in the former article is desirable, the "*w*" given by method (*a*) being too high, and that by method (*d*) probably too low.

The effective pitch is introduced into the formula and is assumed to be 1·1 times the face pitch: the remainder of the

formula stands as given, and 90 per cent. of the thrust thus given is assumed to be that produced.

$$\text{Corrected T} = yD^2V^2p\,(1-s)^2\,B\left(\frac{p+21}{p}\right)0{\cdot}1455 \times 0{\cdot}9.$$

In the case of the *Suecia*, D = 10 ft.: pitch becomes 8·16 ft. × 1·1 = 9 ft., and at 149 revolutions $Vp = \frac{149 \times 9}{101{\cdot}3} = 13{\cdot}22$; then $D^2V^2p\left(\frac{p+21}{p}\right) = 100 \times 175 \times \frac{21{\cdot}9}{0{\cdot}9} = 426{,}000$, which divided by basic case = 1·93, and thrust at 30 per cent. slip = 3·46 × 1·93 × 0·9 = 6 tons.

This T agrees with that given in the table of analysis in the former article; the real advantage of the amended formula is apparent when the corrected speed is estimated. The real slip at which the required T is given is practically 55 per cent., and the $V_1 = 13{\cdot}22 \times 0{\cdot}45 = 6$ knots. The corresponding "w" $= \frac{11-6}{6} = 0{\cdot}83$.

It is, of course, evident that this amendment to the thrust formula has been suggested by the results given on Fig. 5.

Application of the formula to known cases.

A paper was given by Professor Everett at the recent meetings of the American Society of Naval Architects and Marine Engineers on "Power and Speed Trials of 10,000-ton dead weight Steamer." These results were very fully given, and the model of the ship was run in the Washington tank.

The particulars of the vessel and her results were as below.

The thrust being produced by the screw when revolving at 83 revolutions at a real slip of 30 per cent. is estimated as follows: $\left(Vp \text{ being } \frac{83 \times 17{\cdot}05}{101{\cdot}3} = 13{\cdot}94 \text{ knots}\right)$

$$\text{Thrust in tons} = y\,D^2\,V^2p\,(1-s)^2\,B\left(\frac{p+21}{p}\right)0{\cdot}1455 \times 0{\cdot}9$$
$$= 0{\cdot}00192 \times 324 \times 194{\cdot}4 \times 0{\cdot}49 \times 0{\cdot}115 \times \frac{21{\cdot}921}{0{\cdot}921} \times 0{\cdot}1455 \times 0{\cdot}9$$
$$= 21{\cdot}2 \text{ at 30 per cent. slip.}$$

Refer now to Fig. 6. On this is shown a curve of the required thrust in tons proper to the speed base. The calculated Vp (*i.e.*, 13·94 knots for 83 revolutions) is shown. The speed appropriate to 30 per cent. slip = 13·94 × 0·7 = 9·75 knots: at this point the calculated thrust 21·2 tons is plotted and a straight line drawn from 0 thrust (*i.e.*, 13·94 knots) through this spot. It is found that the required thrust is given at a speed of 8·1 knots. By this method of plotting the point at which the required thrust is given indicates at once the speed corrected for wake.

Knowing now the speed of propeller $Vp = 13{\cdot}94$ knots,
the speed of ship $V = 12$ knots,
the speed corrected $V_1 = 8{\cdot}1$ knots,
the real slip and the wake fraction can be found.

$$(1-s) = \frac{V_1}{Vp} \quad \therefore\ s = 0{\cdot}42.$$

$$(1+w) = \frac{V-V_1}{V_1} \quad \therefore\ w = 0{\cdot}482.$$

At the above real slip the efficiency of the propeller = 0·61 (see Figs. 1 and 4) with the ascertained "w" and 0·25 thrust deduction the hull efficiency = 1·112. The propulsive efficiency obtained on trial = 0·58; the hull appendage factor = 0·97; the mechanical efficiency therefore becoming:

$$\frac{0{\cdot}58}{1{\cdot}112 \times 0{\cdot}61 \times 0{\cdot}97} = 0{\cdot}88.$$

This result is probably rather flattering to the efficiency of the machinery, but if that value be reduced either the propeller or the hull efficiencies would require to be increased. The wake value seems just right in the light of McEntee's experiments; a reduction in the thrust deduction would bring about the necessary increase in the hull efficiency. On the whole the analysis works out satisfactorily and affords justification for proceeding to unknown cases.

Having found the wake speed it is possible to arrive at the revolutions for any particular velocity if it be assumed that the wake is not affected by speed. The curve "V_1" has been drawn on Fig. 6 on this assumption; the Vp at 0 thrust, the V_1 at 30 per cent. slip, and the thrust in tons at 30 per cent. slip have been calculated for 50, 60 and 70 revolutions as follows:—

Revs.	Vp at 0 thrust.	V^2p.	Thrust in Tons at 30 per cent. slip.	V_c at 30 per cent. slip.
83	13·94	195	21·2	9·75
70	11·78	138·5	$\frac{138{\cdot}5}{195} \times 21{\cdot}2 = 15{\cdot}1$	8·22
60	10·10	102	$\frac{102}{195} \times 21{\cdot}2 = 11{\cdot}1$	7·05
50	8·41	71	$\frac{71}{195} \times 21{\cdot}2 = 7{\cdot}7$	5·87

10,000-Ton Deadweight Steamer.

Length, 419 ft. 3 in.; breadth, moulded, 56 ft. 3 in.; draught, mean, 25 ft. 6¾ in.; displacement, 13,390 tons; propeller, 4 bronze blades: 18 ft. diam.; 15 ft. 6 in. pitch face); effective pitch, 1·1 × 15·5 = 17·05 ft.; pitch ratio (effective) $= \frac{17{\cdot}05}{18} = 0{\cdot}921$.

(Reciprocating machinery.

Speed in Knots.	Revs.	I.H.P.	$\frac{\Delta_3^2\ V^3}{\text{I.H.P.}}$	Propulsive Coefficient.	E.H.P.	Resistance in Tons $\frac{\text{E.H.P.} \times 0{\cdot}1455}{V}$	Required Thrust in Tons.
6	42·6	443	275	·46	204	4·9	6·74
8	56·3	975	296	·52	506	9·2	12·64
10	69·9	1,835	308	·53	971	14·2	19·5
11	76·3	2,392	311	·55	1,320	17·45	24·0
12	83·0	3,090	315	·58	1,795	21·7	29·8

(The required thrust in tons has been estimated on the basis of 3 per cent. increase in resistance for appendages and 25 per cent. thrust deduction, *i.e.*, H.A.F. = 0·97; $(1-t)$ = 0·75.)

At the latter speeds (*i.e.*, V_c at 30 per cent. slip) plot the values of the calculated thrusts, and from the points at which the lines drawn from the Vp of 0 thrust for these revolutions cross the V_1 line draw lines parallel to the base line back to the required thrust curve (see Fig. 6). Thus 50 revolutions would give a speed of ship of 7·3 knots; 60 revolutions a speed of 8·8 knots, and so on. If a line be drawn through the revolutions so obtained it will be found to agree closely with that actually given from trial results.

Reconsideration of the Cases of the "Suecia" and "Prinsessan Ingeborg."

Having, to some extent, found justification for the amended thrust formula and the new method of plotting, the cases of the *Suecia* and *Prinsessan Ingeborg* are considered. The particulars of these vessels were given in the previous article; they were almost alike in dimensions, the *Suecia* being a twin-screw

motor ship, the *Prinsessan Ingeborg* a single-screw steamer. Particulars of their propellers, their Vp, taking effective pitch into consideration, and the calculated thrusts at 30 per cent. slip, are as given in the following table :—

——	Diam.	Pitch face.	Pitch effective.	Revs. at 11 knots.	Vp.	Thrust at 30 per cent. slip.
	ft.	ft.	ft.			tons.
Suecia	10	8·16	9	149	13·22	6·02
Prinsessan Ingeborg	17·5	17·5	19·25	67·5	12·82	14·3

rected of 6 knots is obtained assuming the total thrust required at 11 knots to be 10·75 tons (one screw) and a speed corrected of 6·5 knots assuming the thrust required to be 10 tons. The resulting analysis is given in table at foot of this page.

From the analysis below it appears that case (*b*) gives values nearer to anticipated values of wake and mechanical efficiency.

Consider now the *Prinsessan Ingeborg*. In her case—being a single-screw steamer—3 per cent. has been allowed for hull appendages and a thrust deduction of 25 per cent., the total estimated thrust being 19·62 tons. The speed corrected is 7·6 knots, the corresponding wake fraction being $\frac{11 - 7{\cdot}6}{7{\cdot}6} = 0{\cdot}447$. Vp being 12·82

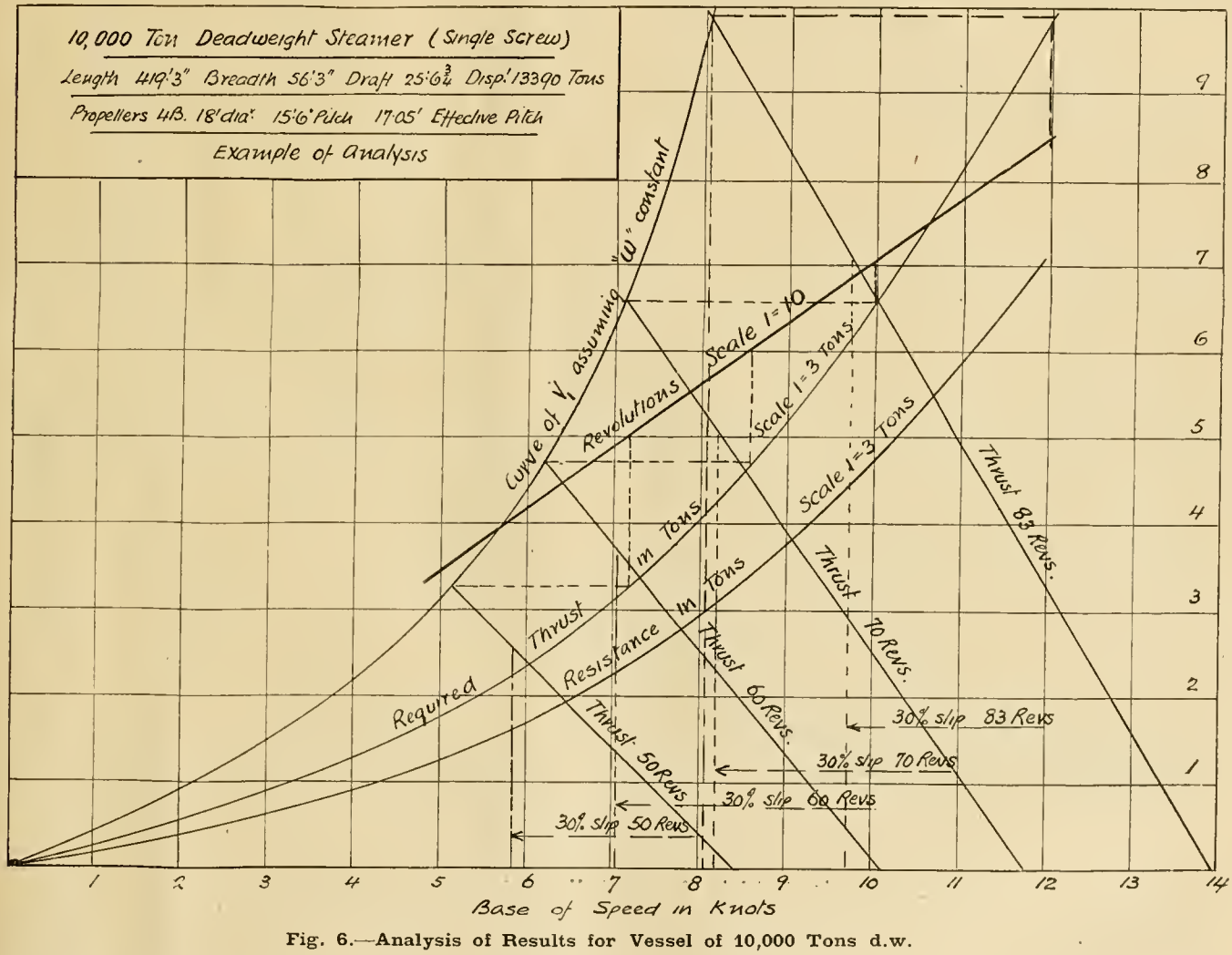


Fig. 6.—Analysis of Results for Vessel of 10,000 Tons d.w.

On Fig. 7 are shown the results of the analysis. The effective horse-powers at various speeds of the *Suecia* have been calculated and half the resistance in tons plotted. In order to arrive at some idea as to the effect on the wake value of over-estimation of the appendage resistance or of the thrust deduction two assumptions have been made, viz.: (*a*) with H.A.F. = 0·885 and "t" = 0·2; and (*b*) with H.A.F. = 0·9 and "t" = 0·15. Curves of required thrusts have been drawn on these assumptions. The method of plotting the thrust of the propeller is as that described above for Fig. 6. It is found that a speed cor-

Case.	$\frac{V - V_1}{V_1}$ "w"	"t"	H.E. $(1+w)\ (1-t)$	H.A.F.	Real Slip.	Efficiency of Screw.	Mechanical Efficiency.	Propulsive Efficiency.
(*a*)	·83	·20	1·465	·885	·546	·50	·83	·538
(*b*)	·69	·15	1·435	·9	·508	·53	·785	·538

Or (*a*) 1·465 × ·885 × ·50 × ·83 = ·538.
(*b*) 1·435 × ·9 × ·53 × ·785 = ·538.

NOTE.—The propeller efficiencies are taken from Fig. 4.

knots and $V_1 = Vp\ (1 - s)$ the real slip becomes 0·408, at which real slip the propeller efficiency becomes 62 per cent. The propulsive efficiency obtained was 52·7 per cent.; the various factors therefore become :—

H.E.		H.A.F.		Propeller E.		Engine E.		Propulsive E.
1·085	×	·97	×	·62	×	·805	=	·527

If these values be compared with those given for the 10,000-ton d.w. steamer a close agreement will be seen to exist except in the case of the engine efficiency. A wake of 45 per cent. in the *Prinsessan Ingeborg* compares with one of 48 per cent. in the vessel referred to, and both in turn agree very well with the wake values for single-screw ships given on Fig. 3.

a thrust of only 6·5 tons would be given whereas an actual thrust of 10 tons is required.

(2) That in the case of the *Suecia*—by using the same method of analysis—it is clearly shown on Fig. 7 that at any given speed the thrust being given by the two screws of the *Suecia* do not equal that being given by the single screw of the *Prinsessan Ingeborg*. The total thrust required is approximately the same in both ships. If the smaller screws of the *Suecia* are not giving out the equivalent thrust at a definite real slip *they must have been performing at a higher real slip*, The Vp, or actual speed of propellers, were roughly the same; the greater slip induces, evidently, a greater wake.

(3) That the intensity of wake measured depends to some,

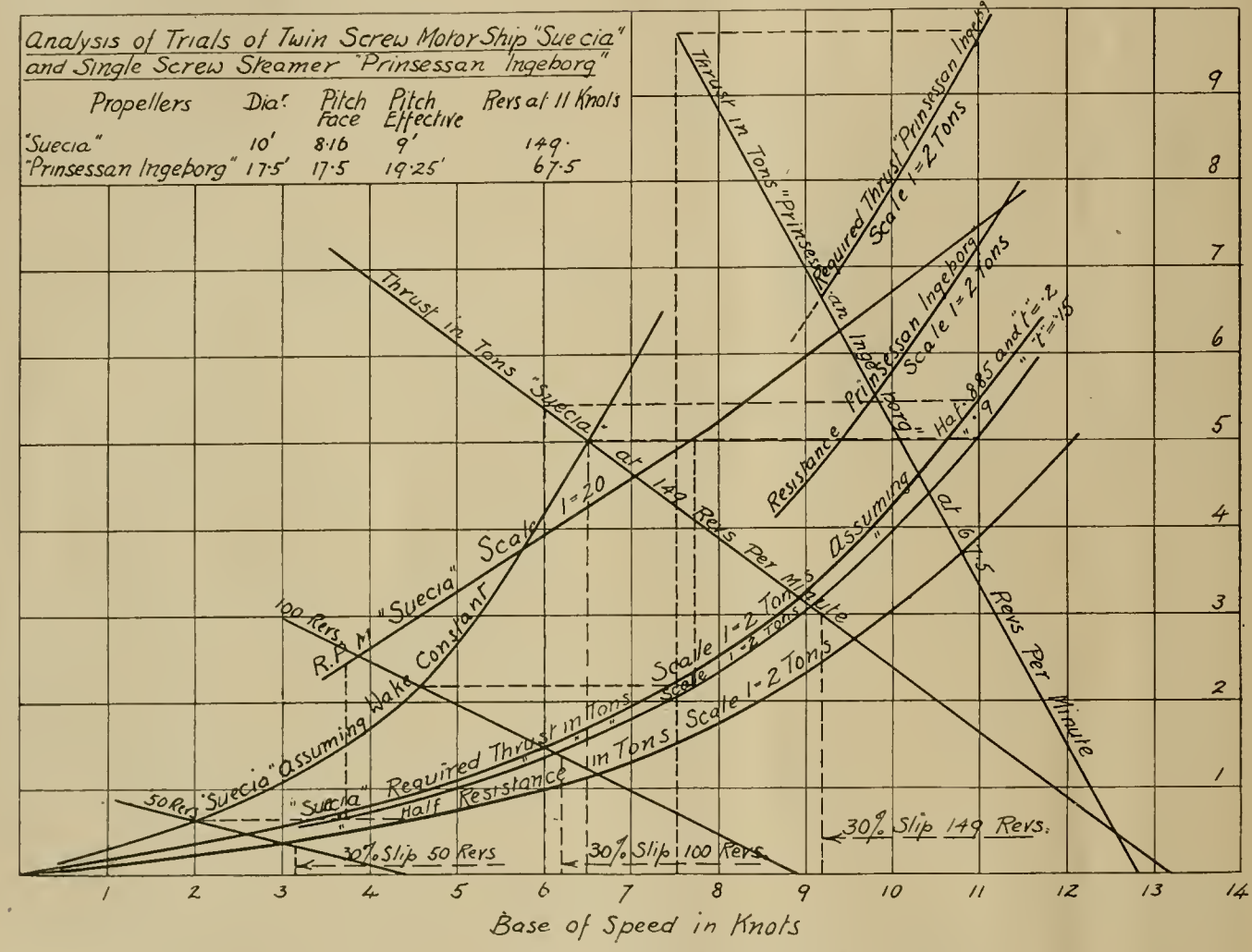

Analysis of Trials of Twin Screw Motor Ship "Suecia" and Single Screw Steamer "Prinsessan Ingeborg"
Propellers Dia. Pitch Face Pitch Effective Revs at 11 Knots
"Suecia" 10' 8·16 9' 149·
"Prinsessan Ingeborg" 17·5' 17·5 19·25' 67·5
Thrust in Tons "Prinsessan Ingeborg"
Required Thrust "Prinsessan Ingeborg" Scale 1=2 Tons
Thrust in Tons "Suecia" at 149 Revs Per Minute
Resistance Prinsessan Ingeborg" Half ·885 and "t=·2 " " ·9 "t=·18
Scale 1=2 Tons
Scale 1=20
100 Revs R.P.M. "Suecia"
Assuming Wake Constant
Assuming at 67·5 Revs Per Minute
Scale 1-2 Tons
50 Revs "Suecia" Assuming Wake Constant
"Suecia" Required Thrust in Tons
" Half Resistance
30% Slip 50 Revs
30% Slip 100 Revs
30% Slip 149 Revs.
Base of Speed in Knots

Fig. 7.—Analysis of Trials of "Suecia" and "Prinsessan Ingeborg."

Wake Values for Twin-Screw Motor Ships.

If the above analysis is reliable it points to the possibility that the wakes of twin-screw motor ships are really greater than those of single-screw vessels. This conclusion is in direct conflict with what Mr. Blache said in the paper which directed the attention of the present writer to the subject. It is also in conflict with the present writer's own ideas before this analysis was undertaken. One or two strong arguments, however, can be put forward to prove that this may be the case. These will now be stated: (1) That at the ρ value calculated by Mr. Blache from McDermott's wake formula the *Suecia's* propeller is not giving out the necessary thrust to overcome the augmented resistance of the ship. The calculated ρ value was 15·76: in the calculation at the beginning of this present article it is shown that at that ρ value

and probably a large, extent on the diameter of the screw. When small propellers are attached behind bossings they will be performing close to the frictional belt near the skin of the ship, and also to that created by the surface of the bossings. The larger the screws are the less affected they will be thereby. This is clearly demonstrated if the trials of twin-screw ships with large propellers are analysed on the same lines as has been suggested in this article. This the writer has done, and finds wake values quite normal in amount and more in harmony with those suggested by McDermott. When small screws are revolving at high revolutions for the propulsion of heavy and full ships these normal wake values do not seem to hold.

Interesting Points disclosed by this Analysis.

One or two rather interesting points have been disclosed by this analysis. It appears, for example, that the curves for

propeller design in Taylor's speed and power of ships have not a range suitable for twin-screw Diesel-engined ships.

Beyond the range of Taylor's ρ δ Diagrams.

Suppose that the wakes found for the *Suecia* by analysis be accepted, then Taylor's $\rho = \frac{RP^{\frac{1}{2}}}{V_1^{\frac{5}{2}}}$

where R = revolutions per minute.
P = power absorbed or S.H.P.
V_1 = speed corrected for wake.

In the *Suecia*, R = 149; S.H.P. = 1,070 × 0·785 = 840; and V_1 = 6·5 (as per (*b*) analysis);

$$\text{then } \rho = \frac{149 \times 29}{107 \cdot 5} = 40 \cdot 2.$$

Taylor's values in the diagrams 211·2·3 do not go beyond $\rho = 30$.

Some other method of design must therefore be chosen.

Untrustworthiness of Thrust Horse power as a Basis of Design.

In some analyses of the performances of the centre screws in "combination" jobs, where relatively small propellers were being driven by a turbine using the exhaust steam from wing reciprocating engines, the writer tried some years ago, unsuccessfully, to arrive at some idea as to the conditions under which they were working. Unfortunately the importance of endeavouring to find out the wake proper to a certain thrust was overlooked and attention was given to power instead. By referring to Fig. 5 it will be seen that the T.H.P. is practically constant from 30 to 60 per cent. slip, whereas the thrust in tons is a definitely increasing value. A combined use of Froude's amended thrust formula, as suggested in this present article, and of his curves of design (Fig. 1), should afford a sound basis for arriving at propeller dimensions.

In the case of the *Suecia*, (*b*) analysis, with these curves,

$$C_A = \frac{R^2H}{BV_1^5} \quad : \quad C_o = \frac{H}{BD^2V_1^3}.$$

The calculated thrust = 10 tons and V_1 = 6·5 knots; then

$$H = \frac{10 \times 6 \cdot 5}{0 \cdot 1455} = 447.$$

For wake analysis it has been assumed that only 90 per cent. of the thrust as given by Froude's formula is actually given out by the screw. For purposes of design it must be reckoned that the full thrust is being given. The thrust for design, therefore, in above case $= \frac{10}{\cdot 9} = 11 \cdot 11$ tons, accordingly the H becomes 497.

Further—

$$R = 149, \quad R \text{ in above formula} = \frac{\text{Revs. per min.}}{100}$$

$$\therefore \quad R^2 = 2 \cdot 22.$$

$$B = 0 \cdot 115 : \quad V_1 = 6 \cdot 5, \quad V_1^3 = 274, \quad V_1^5 = 11{,}550.$$

$$\text{Then } C_A = \frac{2 \cdot 22 \times 497}{0 \cdot 115 \times 11{,}550} = \cdot 830.$$

Refer now to Fig. 1. At this C value the pitch ratio of maximum efficiency is 0·8, at which pitch ratio C_o = 0·144. At pitch ratio = 0·9 the C_o = 0·158.

Then with C_o = 0·144, D^2 becomes $\frac{497}{0 \cdot 115 \times 0 \cdot 144 \times 274} =$ 109·5, D becoming 10·45 ft. and pitch 8·36 ft. (complete).

With $C_o = 0 \cdot 158$, $D^2 = \frac{497}{0 \cdot 115 \times 0 \cdot 158 \times 274} = 100$, D becoming 10 ft. and pitch 9 ft. (complete).

The latter solution exactly corresponds with the propeller actually fitted, the face pitch being $\frac{9}{1 \cdot 1} = 8 \cdot 16$ ft.

Wake Values to use in Design.

As the result of the foregoing analysis it appears that the wake is dependent on several factors. Hitherto it has been generally accepted that the position of the screw and the fullness of the vessel were the only factors that counted. The writer is of the opinion that the amount of thrust required, the speed of the ship and the diameter of the screw, largely dominate the wake value. To this further reference will be made in the concluding article.

SPEED-REDUCTION GEARING.—(*Concluded from page 55.*)

by being drawn over a system of pipes containing steam fed from a small boiler having a working pressure of 60 lb. per square inch. The air is circulated through the shops by a large Sirocco fan driven by a 25-h.p. motor.

All the machinery is driven by electricity, the power being taken from the supply mains of the Uxbridge Electricity Company and transformed to suit the various requirements in the shops. The power is received at a pressure of 2,700 volts single-phase alternating, and it is transformed for general purposes down to 220 volts. The power-house containing the rotary transformers and switchboard is shown on page 59. The large rotary transformer facing the centre of the switchboard is of 500-h.p. capacity, built by Bruce, Peebles Limited, Edinburgh. It consists of a single-phase motor, running at 750 r.p.m., with two generators one on either end of the motor shaft, one generating direct current and the other three-phase alternating current. The direct current is utilised for driving the variable speed motors and for lighting, while the alternating current is for driving various constant-speed motors. There are two smaller rotary transformers supplied by the Brush Electrical Company. The small machine seen near the switchboard is a special rotary transformer for supplying the large planing machine the reversing motor of which might upset the running of the other machines. An overhead travelling crane of 5 tons capacity, by Morris Limited, Loughborough, is installed in the power-house. In an annexe to the power-house there is an electrically-driven air compressing plant. The compressor is by Broom & Wade, and has a cylinder 5 in. diam. by 6 in. stroke, the working pressure being 90 lb. per square inch. It is driven by a 25-h.p. Westinghouse motor.

The Power Plant Company have just completed an order for two sets of double-reduction marine turbine gears for the Fijenoord Shipbuilding Company, Rotterdam, for the ss. *Dinkelstroom* and ss. *Reggestroom*. These gears will transmit 1,800-h.p., reducing the speed from 4,000 r.p.m. at the turbines to 80 r.p.m. at the propeller shaft, the turbines for which have been constructed to the designs of Escher Weiss & Co., of Zurich.

A view of the gears for the latter vessel taken in the shop just prior to despatch is shown on page 60. The casing for the gears, together with the Michell thrust block, is seen erected near the gear wheels. Other examples of marine gears are reproduced on pages 56 and 60, showing that the Power Plant Company have been responsible for some of the largest marine gears ever constructed, including those for the famous battle-cruiser *Queen Elizabeth*, as well as for numerous smaller war vessels, such as high-speed destroyers. In addition, they construct smaller gears for ships' lighting sets, as well as for the many purposes for which mechanical gearing is employed on land.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Dutch Shipbuilding, 1921.

Very complete statistical data of the whole of the ships built in Holland during the past year have been placed at the disposal of the publication by the Dutch shipbuilders. The builders are classified alphabetically, and for each of the vessels built by them, the name, owners, type of ship, deadweight, length, breadth, depth and engine builders' type, and horse-power of engine are given, the total list embracing over 500 vessels of all descriptions. In the succeeding issue similar particulars of all vessels in course of construction on January 1, 1922, are to be given.—*Het Schip*, December 30, 1921, page 405; 9 pages.

The Bureau Veritas New Rules.

An examination is made of the more salient features and important modifications appearing in the recently revised edition of the Bureau Veritas rules for the construction of steel vessels. The past progress of the society is briefly reviewed and the various numeral systems previously used are outlined. The success of the society's former decision to make displacement, through the draught, the basis for scantlings has led to the extension and simplification of this principle; types of vessel have been unified and older nomenclature dispensed with. The rules recently in force effected the draught modification by interpolation of actual scantlings; the new rules merely modify the particular numerals and hence eliminate all interpolation. The new rules require heavier scantlings where concentration of stress is likely, but on the other hand the shell throughout has been somewhat reduced. New rules are introduced for determining the scantlings of deck girders, pillars, hatchways and rudder heads. The recommendation of the 1914 Convention *re* W.T. Bulkheads are also included. Rules for the construction of trawlers have been added and many other smaller modifications have been effected.—*Bul. Tech. d. Bureau Veritas*, November, 1921, page 265; 2 pages.

German Marine Diesel-Driven Dynamos.

In a previous series of articles the author has reviewed the general requirements of the German Admiralty with respect to the design and working conditions of Diesel engines for the driving of dynamos in their various classes of naval vessels. The present series aims at describing in full detail the construction and behaviour of the various Diesel engines actually fitted for this purpose. The dynamos throughout had to develop 300 kw. The Junkers engine is first described, every important part being illustrated in complete detail and the subsequent tests given in full. The Junkers engines were made by the A. G. Weser, Bremen, and were fitted in the battleship *Markgraf*. In the next issue the engine built by the Gebr. Körting Company at Körtingsdorf and fitted in the battleship *Konig* is similarly described and the trial results communicated. In the succeeding issue the Krupp engine fitted in the battleship *Kronprinz* is dealt with in the same complete manner. Numerous other engines are to be considered in the future issues of this journal. It is, however, impossible to review the series with any desirable degree of completeness because of the enormous detail and information therein contained.—*Ober-Marinebaurat W. Laudahn, Schiffbau*, December 21, 28, 1921, January 4, 11, 1922; pages 329, 363, 397.

M.S. "Havelland."

The M.S. *Havelland*, recently built by Blohm and Voss for the Hamburg-Amerika Line, is of technical interest because of its having high speed oil engines with reduction gear. The ship itself carries a deadweight of 10,235 tons on a draught of 25 ft. 1⅝ in. The machinery b.h.p. is 2 × 1,650, for a designed speed of 12 knots, and 1,400 tons of oil bunkers are provided. The machinery, which was built by Blohm and Voss, consists of two engines, each having 10 cylinders with a diameter of 530 mm. and 530 mm. stroke. The r.p.m. are 230, which correspond to a piston speed of 4·06 m./sec. The cylinders are sea-water cooled, and the piston oil-cooled. The reduction ratio is 1 : 2·7, giving a propeller revolution of 85. Care was taken in the design of the reduction gear to secure even torque in the teeth, and this evenness was definitely shown on the trial trip. This type of installation effects a saving over the direct type of oil engine of 330 tons in weight and 6,000 cubic ft. in space. All auxiliaries, including 13 winches and steering engine, are electrically driven. Use is made of the exhaust gases for heating rooms, &c. The trial took place on August 30, 1921, when a fuel consumption of 136 gm. per b.h.p./hour was obtained. The maiden voyage was made to New Orleans, when an average b.h.p. of 3,603 was developed, giving on a mean draught a speed of 11·12 knots with an average fuel consumption of 130 gm. per b.h.p./hour.—*Schiffbau, J.* XXIII.

Motor Installations for Small Ships.

The present and established makes of internal-combustion engines are reviewed in order to consider their possible application for both main and auxiliary purposes in such small craft as river vessels, barges, tugs and fishing vessels. The auxiliary applications are first dealt with. These are many and embrace those formerly driven by steam such as winches, windlasses and steering gear. In view of the present desire to eliminate as much labour as possible a further application could be made to winches where these formerly could not be fitted, *e.g.*, as in such non-self-propelled craft as barges, &c. The Deutz C.M. motor of 4 to 8 b.h.p., using benzol, petroleum or benzine, is first described and recommended. Sketches showing its adaptation for winches and windlasses in several alternative positions are given. Benzine is generally the fuel used, because in the case of crude-oil motors the difficulty of rapid starting is and has been considerable. The high-pressure crude-oil motor made by Benz & Co., of Mannheim, is, however, an important exception, and in view of the present relative cheapness of crude oil the possibilities of this engine are considered in similar applications to the Deutz. Main machinery applications are then dealt with. Details of a Benz 200 b.h.p. two-stroke Diesel engine are given, having a fuel consumption of ·44 lb. per b.h.p. hour. This engine is specially suitable for small passenger vessels and tugs; photographs of such craft are given. For the still smaller vessel such as small fishing vessels the Hanomag-Lloyd and the Deutz-Brons motors are very suitable and are in considerable favour. The motor which is in greatest universal favour is undoubtedly the Kromhout (average pressure) two-stroke motor. It is the simplest and most efficient motor in use. It is applicable over the whole range of small vessels; its various applications are considered and illustrated.—*Der Kleinschiffbau*, November 12, 26, 1921; pages 227, 249; 12 pages; 19 ff.

Model Experiments for Motor Fishing Boat.

Full particulars of the form and dimensions of a motor fishing boat built by the Pommern Werft, of Swinemünde, are given and very complete results are supplied of the model experiments which were carried out by Dr. Schaffran to determine the economical speed and most suitable size and type of propeller for the vessel. The principal dimensions of the craft are as follows: length 35 ft., mean draught 3·18 ft., block coefficienet ·307, midship section coefficient ·551, and a displacement of 9·80 tons. The experiments were made over a range representing from 2 to 8 knots and an economical speed of 6·1 knots was obtained. Photographs showing the excessive wave formation above this speed verify this result very clearly. In the actual vessel it was desired to make use of a 15 b.h.p. Callesen crude-oil motor which developed its maximum power at 420 r.p.m. Propeller experiments showed that a maximum efficiency of 59 per cent. was obtainable with a two-bladed propeller 2·35 ft. diam., 2·12 ft. pitch and ·28 disc area ratio when working at these revolutions. A maximum speed of 6·64 knots was obtainable with the given horse-power of the engine. Research was also made to test the suitability of this propeller at a trawling speed of 2·5 knots. It was found that the vessel could tow 225 kg. at this speed, or in other words could tow 15 kg. per b.h.p. In order to maintain the revolutions at 420, for economy of fuel, the pitch of the propeller must be reduced mechanically to 1·78 ft., the propeller efficiency being then only 28·5 per cent. The article deals very thoroughly with the powering of this class of vessel.—*Dr. K. Schaffran, Der Kleinschiffbau*, December 10 and 24; Vol. I, pages 271, 287; 8 pages; 12 ff.

Classification of Shipbuilding and Marine Engineering Literature.

The valuable contributions made in the shipbuilding and marine engineering press cannot be neglected or thrown aside by those who wish to be up to date in their profession. Many partial indexes are supplied by the respective journals to facilitate reference work, but none can make any claim to completeness. The author has therefore prepared a remarkably complete classification of the subjects, only the broad divisions of which can be given here. These are given in tabular form below.

Main Divisions.	Sub-Divisions.
Shipbuilding ...	Theory, design, construction, standard details, conversion work, historical.
Marine engineering	Ship propulsion, main machinery, auxiliary machinery, propellers, boilers, machine parts, standard work, trial data.
Yard and factory lay-out.	Descriptive, outfit and plant, working methods, the worker, organisation, economics, historical.
Shipping	Lines, ship running, geographical data, economics, military data, pleasure traffic.
Technology ...	Raw materials, manufactured materials, material prices, testing of materials, general.
Pure science ...	Mathematics, physics, chemistry.
Aeronautics ...	Construction and type, descriptive, propulsion, research, theory of flight.

When such a classification is conscientiously carried out it would be possible to avail oneself at a moment's notice of the vast amount of valuable information contained in the technical press.—*Dr. W. V. Mendl, Schiffbau*, December 21, 1921, page 339; 4 pages.

Gyroscopic Stabilisation of Ships.

The article deals entirely with the Sperry gyroscope and its application to ships. The first successful installation was in 1911. In 1914 the English Admiralty considered its adoption on the T.B.D. *Hampshire*, but owing to the war this was prevented. Trials on the S.Y. *Lyndonia* established the efficacy of the Sperry installation, and on a voyage to the West Indies an inclination of 40 deg. was reduced to 2 deg. in a single oscillation. The Italian Admiralty had also intended fitting the Sperry installation in four hydrographic vessels of 1,500 tons and also embodied it in the design of the 40,000-ton battleships. The war interfered and all were discontinued with the exception of one hydrographic vessel, the *Guglielmo Pepe*, which it is claimed is the first European naval vessel to be so equipped. The American Shipping Board and also the Japanese Government have recently ordered installations.

The subject has been studied experimentally by McEntee in the Washington tank on a 23-ft. model of the American aircraft carrier *Langley*. A roll of 25 deg. was set up, and when the model was towed at a speed corresponding to a ship speed of 15 knots a diminution of resistance of 10 per cent. was found when the gyroscope was in action. Similarly for a roll of 45 deg. reduction of 20 per cent. in the resistance was obtained. A further simultaneous advantage is the case of steering in a heavy sea. The Sperry installation is undoubtedly a commercial proposition and does not absorb valuable deadweight space, because when it is fitted the customary reserve engine power can be considerably dispensed with. It is claimed that the Sperry is easily the best of all systems in use. The installation is described and a diagrammatic sketch is given.—*La Marina Mercantile Italiana*, November, 1921, page 321; 2 pages; 1 f.

Trend of River Craft Design.

The increasing demands of passenger and goods traffic on the German canals have resulted in increased size and number of vessels therein engaged. The growth in size was at first one of overall dimensions, but the limitations imposed by local conditions prevent further absolute increase and nowadays the tendency is rather towards increasing fullness. This is especially the case with barges and tugs, but only to a very slight degree the case with passenger vessels. The form of these river craft was determined largely in the past also by local considerations. Thus the flat bottom and shallow draught with spoon rather than wedge ends are the universal features of river craft. The passenger vessel is especially investigated by the author. From a detailed longitudinal strength calculation of a 260-ft. Rhine paddle steamer he shows that an increase in draught from 3·25 ft. to 3·9 ft. with a corresponding decrease in the prismatic coefficient from ·795 to ·658 reduced the bending moment amidships (assuming same structural weight distribution) from 2,950 ft. tons to 1,300 ft. tons. Further, in order that an even distribution of passengers throughout the length may not affect the bending moment it follows that the waterplane coefficient must be as high as possible. The actual development is thus explained. While increased length would have admitted a higher block coefficient this is prevented—so long as the draught is restricted—by considerations of structural strength. The case of tugs is different, for here any extra load, *i.e.*, bunkers, comes amidships, and hence for structural reasons a fine water line is necessary. Thus for the two types the form is definitely fixed by the relation of the block to the waterplane coefficient, the passenger vessel requiring spoon, and the tug wedge, ends. The passenger vessel investigation is extended to the determination of scantlings of plating and particularly the Sponson beams. For these latter a complete bulkhead in way of each is recommended instead of the customary strong beams, weight being actually saved as a result. The investigation serves to show the justification for past and gives suggestions for the future trend of river craft design.—*J. Stieghorst, Der Kleinschiffbau*, December 10, 24, Vol. 1, pages 267, 285; 7 pages, 13 ff.

Inter-Relation of Ship and Propeller.

Probably no branch of naval architecture has produced so much controversy as that of the conception of wake. Recent research in Germany by Dr. Immich seemed to establish a constant hull efficiency of unity (*i.e.*, $Tv = Rv_s$) a result which is opposed to the view usually held. The author sets himself the task of testing the validity of this assertion and deals very thoroughly with the problem. He finds that for the analysis of the propeller interaction the total wake effect should be split up into hydraulic and frictional wakes. The hydraulic wake is produced through the movement of the water round the hull and contains no individual energy. The work done by the propeller (*i.e.*, Tv) is always equal to that required to overcome the ship's resistance (*i.e.*, Rv_s) and thus the wake and propeller suction factors are equal and the hull efficiency is unity. The hydraulic wake has therefore generally no effect upon the overall efficiency except of course when associated with a bad form of ship. The frictional wake is produced by the friction of the water at the hull surface and is sustained by the internal friction of the water itself. The work done by the ship in overcoming the frictional resistance reappears in the kinetic energy of the wake. In this case the thrust equality does not hold and generally the hull efficiency is greater than unity. In the case of insufficient propeller clearance bringing with it a reduction of pressure in front of the screw, higher stream velocity will be produced and thus the frictional resistance increased. This effect is known as the friction suction; and when it is present the hull efficiency may be less than unity (a value greater than unity being of course possible). Wake generally increases the overall efficiency but not the pure propeller efficiency. If too much frictional suction is produced the overall efficiency may be reduced, but generally in well-designed ships this is not the case and the beneficial effect of wake on hull efficiency more than outweighs its harmful effect on propeller efficiency. The mathematics of the article are made very clear by numerous diagrams.—*R. Fresenius, Schiffbau, J.* XXIII, December 7, 14, 1921, pages 257, 300; 8 pages; 6 ff.

Screw Propeller Design.

When a series of identical vessels are to be constructed the relative accuracy of the model experiment method of design can be appreciably increased by the careful analysis of the trial results of the first completed vessel. The law of similarity is much more reliable when used for the comparison of full-sized vessels than for that of a vessel and its corresponding experiment tank model. To apply the method outlined in the article the resistance results of the model hull (naked), the thrust and torque of the model propeller (in the open), the trial results, *i.e.*, horse-powers, revolutions and apparent slips in the first completed vessel, are all assumed to be known. The fundamental variable in the propeller theory being the slip ratio, it is necessary to know according to what functions of this ratio the thrust and torque may be said to vary. These functions are expressed in terms of constants A, B, C and D which depend upon the pitch, disc area and thickness ratios of the propeller. These constants are obtained from model experiment results, and a table of their values over a range of pitch ratios from ·60 to 1·20, disc area ratios from ·230 to ·537, and thickness ratios from ·15 to ·25, based on Taylor's experiments, are given. The chief difficulty in the correlation of model and full size lies in the

unknown effect of wake in the full-sized vessel, but this can be closely estimated when trial data is available. The method consists in plotting the values of the torque slip function (as calculated from the trial data) upon a base of apparent slip ratio, then, assuming various values of wake factor, the corresponding values as obtained from the model propeller are plotted to the same base and result in a separate curve for each wake factor. From this diagram the value of wake factor in closest agreement with the trial results can be obtained. The method is applied to the analysis of trial results of German submarines, full particulars of which are given. Having obtained the wake factor the problem of the best propeller is dealt with in the usual manner. Various minor problems are considered and the article concludes with a general outline of the applications of the method.—*Prof. Gümbel, Schiffbau, J.* XXIII, December 14, 1921, page 294; 7 pages; 3 ff.

The Form and Contour of Sails.

The form given to sails to-day is almost precisely the same as that in the days of Columbus. This is due not to their being perfect, but to the introduction of coal as a means to propulsion. With the present increase in coal price and uncertainty of the labour market, the resuscitation of the sailing vessel is possible, and the scientific progress in aerodynamics should be examined in order to further this aim. Very little information exists in text-books on Naval Architecture. Many aerodynamical research stations exist in Germany, and owing to the restrictions of the Peace Treaty it is possible that time could be devoted to the naval architectural aspect of aerodynamics. Of leading importance in this connection is the study of the shape of the diametral plane (*i.e.* submerged ship elevation) and the form of sails. Improvements due to fitting of lee-boards of correct shape would involve technical difficulties, but revolutionary changes can be effected in the design of sails. From aerodynamical considerations one must distinguish between sailing before and on the wind. For before-the-wind sailing the maximum wind pressure on the existing sails must be obtained. This problem is analogous to that of the parachute, and experiment and experience have shown very definitely that a circular hole of diameter depending on size and speed of parachute greatly increases its resistance and stability. Parachutes without holes are unstable due to the movement of the centre of pressure. Owing to the changing nature of the wind in the case of the ship the available information on parachutes cannot be immediately utilised, and obviously the holes in various sails would need to differ. Research on the most suitable bellying and curvature of sails is also necessary. For on-the-wind sailing the smallest total pressure on the sail must yield the maximum forward component. All aerodynamical discoveries on form, angle of incidence, &c., can with due consideration be made use of. All constrained sails deform under increasing wind pressure, but the greatest curvature lies in the after third, and not in the forward third, where aerodynamics shows it to be of greatest value. Various types of sail are examined from this standpoint. The eddying behind masts and rigging must also be considered.

In conclusion, the author shows how practice will somewhat prevent the immediate embodiment of aerodynamic research, and points out that this latter should now be directed to the study of the problem as presented by the sailing ship.—*Prof. K. Wegener, Schiffbau, J.* XXIII.

Auxiliary Sailing Vessels.

The present economic conditions in Germany are tending to direct attention to the auxiliary sailing vessel. Messrs. Krupp having ceased to build submarines at their Germania werft are converting some of their facilities in order to build these auxiliary craft. Preliminary experiments were made with ordinary existing vessels, and such successful results were obtained that Messrs. Krupp set out to build 40 vessels of nine distinct types. The vessels are complete as "Sailers," the motor being essentially for auxiliary purposes. A number of these vessels have been built, and after expert examination on trial in heavy weather have been pronounced as highly efficient. Plans and elevations of the three-masted motor schooner and of the motor galliott are given in the article. The following list gives fairly complete particulars of the types under construction.

TYPES OF AUXILIARY SAILING VESSELS UNDER CONSTRUCTION.

Type.		S. 372	S. 373	S. 376/7	S. 378/80	S. 381/4	S. 385/8	S. 389/96	S. 397/408	S. 420/24
		Four-masted Barque.	Three-mast Topsail Schooners.				Two-mast F. & A. Schooner.	Galliott.	Galleass.	Five-mast Schooners.
Length between perpendiculars	metres.	97·90	43·4	45·0	45·0	33·0	26·0	28·4	22·70	77·0
Breadth, moulded	,,	14·60	8·70	8·996	8·996	7·48	6·25	6·75	5·60	13·45
Depth	,,	8·72	4·87	4·10	4·10	3·35	3·09	2·40	2·30	6·60
Draught	,,	7·46	{4·57 / 4·33}	3·84	3·905	3·15	2·91	2·06	2·275	—
Deadweight	Tons.	5,212	345	625	645	290	175	195	115	2,400
Tonnage—										
Gross	Reg. tons.	3,200*	400*	456	456	192*	125	139	78	1,810*
Net	,,	2,600*	—	339	339	144*	91	98	57	1,400*
Water ballast	Cubic metres.	480	75	59	59	40	23	41	5	210
Machinery	.. ..	Diesel 4-Stroke.	Diesel 4-Stroke.	Diesel 4-Stroke.	Diesel 4-Stroke.	2-Cyl. Hot Bulb.	2-Cyl. Hot Bulb.	2-Cyl. Hot Bulb.	Hot Bulb.	Diesel 4-Stroke.
Horse power	.. ..	550	160	160	160	80	50	40	25	275
Speed	Knots.	6·0*	8·0	7·5	7·5	6*	6	5	5	6·5*
Bunkers (Oil)	Tons.	110	22	12	12	8	2	1·5	1·5	40
Sail Area	m^2	3,392	1,050	883	883	490	308	340	225	1,863

* Approximate.

All vessels built to German Lloyd's, with the exception of S. 373, which is Bureau Veritas. —*Schiffbau, J.* XXII.

DRILL TESTS FOR MARINE BOILERS.—II.—(*Concluded from page* 78.)

cylindrical boilers, deflection meters should be used for ascertaining the deflection in the furnaces, combustion chambers, or any other part of the boiler considered necessary. The deflection meter must be set at zero at the commencement of the test, and observations as to the amount of deflection, whether compression or expansion, taken as the pressure increases. As the pressure is relaxed, the pointers should return to zero.

When water-pressure testing water-tube boilers fitted with curved tubes, observations must be taken with a view to detecting any change of configuration of the tubes. Should any permanent deformation be observed during the test, the pressure is to be released immediately. If it is not possible to strengthen the weak parts, it is advisable to adopt a new test and working pressure, the test pressure being 20 lb. below the pressure at which the deformation commenced, the new working pressure corresponding with the new test pressure. In such case the load on the safety valves must of course be reduced to the new working pressure. It is usual after the drill test to test the steam pipes as far as the engines in the same manner, and with the same pressure, as that applied to the boiler.

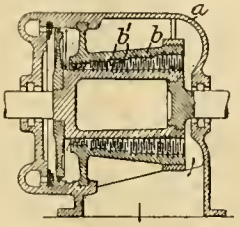
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 171,395. Turbines.

Erste Brünner Maschinen-Fabriks Ges., 5, Glockengasse, and Losel, F., both in Brunn, Czecho-Slovakia. November 10, 1921, *No.* 30021. *Convention date, November* 11, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

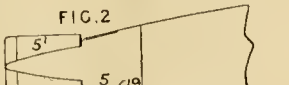
In a combined impulse and reaction turbine, the whole of the guide-blades b^1 of the reaction portion are enclosed in a separate casing b which is fitted afterwards into the main casing a.

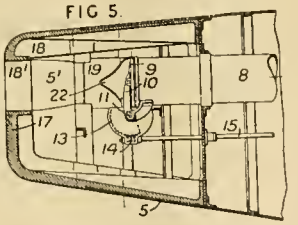


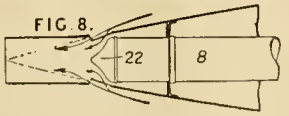
No. 171,446. Submarine Vessels.

Fairweather, W. C., 65, Chancery Lane, London.—(Lake Torpedo Boat Company; Bridgeport, Connecticut, U.S.A.) August 4, 1920, *No.* 22975. [*Classes* 9 (ii) *and* 113 (ii).]

A submarine torpedo boat is provided with a torpedo tube opening through the stern with a valve closure 9, Fig. 5, for the muzzle end of the tube 8, and a cylindrical tubular stern section 5^1, Figs. 2 and 5, which is open to the water at both ends. The valve 9 is pivotally mounted to an arm 10, hinged at 11, operated from a shaft 15 within the hull by means of worm and segment gearing 13, 14. The shell 5 of the stern section is provided with side openings 19 and is supported in arms 18 extending forwardly from a stern post having a circular opening 18^1 and a vertical post 17. The valve closure 9 is fitted at the rear with a cone-shaped fairwater shell or casing 22 to prevent the formation of eddies at the end of the tube when closed. Fig. 8 shows a modification in which the stern post is dispensed with.



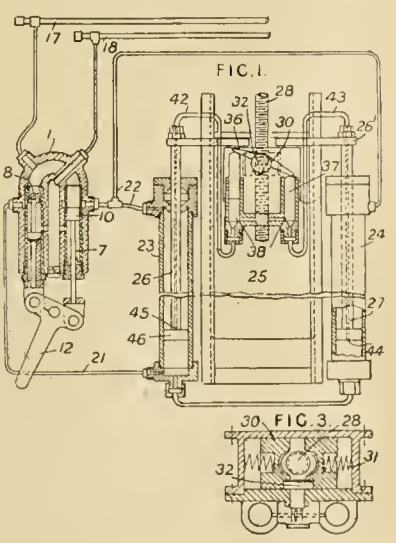




No. 171,454. Operating Ships' Doors.

Anderson, H. P. H., Brantwood, Central Avenue, Welling, Kent. August 10, 1920, *No.* 23392. [*Class* 65 (i).]

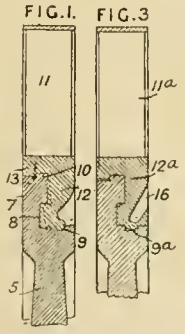
When hydraulic power is in use to move a piston-operated bulkhead door, the hand gear is non-operative, but should the pressure fluid be cut off or fail, the halves of a nut carried by the door are automatically brought into engagement with a screwed shaft for normally operating the door. The fluid pressure is admitted from one of the mains 17, 18 through a local hand-operated valve control device 1 to the cylinders 23, 24 containing respectively pistons 46, 44, having piston rods 26, 27 attached at the upper ends by bracket members 26^1 to the door 25. On the door is mounted a casing containing the halves 30 of a nut, which are forced apart against the action of springs 31 by a lever 32, while the door is operable hydraulically. In the valve casing 1 are pistons 8, 10, the rods 7 of which are secured to a hand lever 12. By adjusting this lever, the pistons are operated so that the pressure and exhaust mains 17, 18 communicate through suitable ports and passages in the valve casing, and the pipes 21, 22 with the upper and lower sides of the piston, thus operating the door. The piston rods are tubular, the rod 26 having an orifice 45 on the upper side of the piston 46, the piston rod 27 communicating with the lower side of the piston 44, as shown. Fluid pressure thus passes either from the upper or lower side respectively of the pistons 46, 44 through pipes 42 or 43 to act on one or other of the piston members 37. These pistons are arranged on either side of a lever 36, which is connected to the arm 32 arranged between the halves 30 of the nut for engaging the shaft 28, by means of which the door is manually operable. By this arrangement, when fluid pressure is acting to move or maintain the door in the open or closed position, the lever 36 is operated by one or other of the piston members 37 to keep the hand gear for the door non-operable, but when the pressure fails or is cut off, the pressure under the sides of the pistons 37 is equalised through a passage 38, and the springs then move the parts 30 of the nut into engagement with the shaft 28.



No. 171,584. Turbines.

British Thomson-Houston Company Limited, 83, Cannon Street, London.—(General Electric Company; Schenectady, New York, U.S.A.) October 8, 1920, *No.* 28545. [*Class* 110 (iii).]

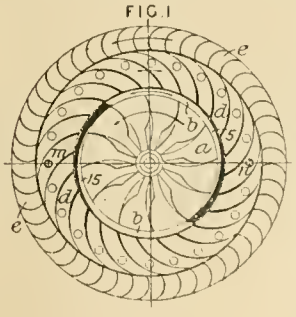
A turbine blade 11 is secured to the rotor 5 by a projection 13 which is hooked over a projection 10 on the rotor flange 7, thereby bringing the blade into a radial position, its leg 12 being in the position shown in dotted lines in Fig. 1. The leg 12 is then staked or driven into recesses 8, 9 by a tool which for emergency repairs may be inserted at a high angle between adjacent rings of blades. In a modification, Fig. 3, after the blade 11^a has been hooked into position the material at the bottom of the hole 16 in the leg $12'$ is driven down into a recess $9'$ in the rotor rim.



No. 171,685. Turbines.

Schultz, E. J. A., 38bis, Avenue de la République, Paris. November 9, 1921, *No.* 29894. *Convention date, November* 19, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

In an internal-combustion turbine, the explosion chambers d are arranged in a stationary member between the turbine wheel e and a ring b rotating therewith. A fan a geared to rotate at twice the speed of the turbine wheel delivers the explosive mixture to the chambers d through opposite ports in the ring b, which is given a varying thickness as shown to provide expanding delivery passages 5, 15. Sparking plugs m, n carried by the turbine wheel register with successive orifices in the stationary chambers d. The walls of the turbine wheel and the combustion chambers may be fitted with ribs for cooling.



No. 171,732. Ships.

Gordon, J. R., 17, West Fiftieth Street, New York, and Simpson, G., 70, Vanderbilt Avenue, Staten Island, both in New York, U.S.A. July 14, 1920, *No.* 21254. [*Classes* 110 (iii), 113 (ii), *and* 114.

In a ship having an unobstructed hold bottom with transmission shafting in an alley or alleys below the floor, the engines or prime movers are located in a narrow machinery compartment 9, Fig. 1, at the forward end of the sub-floor shafting alley 6, whilst the propeller shaft 26 extends into the after-peak compartment 10 which contains reduction gearing 24. The prime movers preferably comprise high and low-pressure turbines geared to the shafting so

that one or both turbines may drive. Two, three, or more such sets of turbines may be used, the shafting being disposed in central and side sub-floor alleys, the aft ends of which are connected by a cross passage having an exit shaft 27 to the deck. Where the shafting is disposed at an angle to the longitudinal centre line of the ship, the power machinery is angularly disposed in the machinery compartment to correspond. Fig. 10 shows an electrical transmission arrangement in which the turbine or turbines drive a generator 40, the transmission cable 37 being disposed in a conduit 36 in the sub-floor alley 6 leading to a motor in the after-peak compartment 10.

FIG. 1.

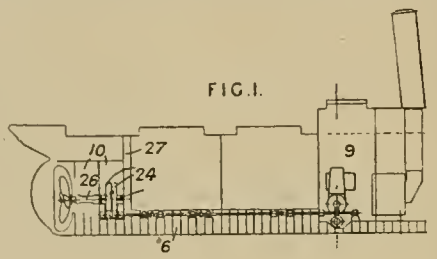
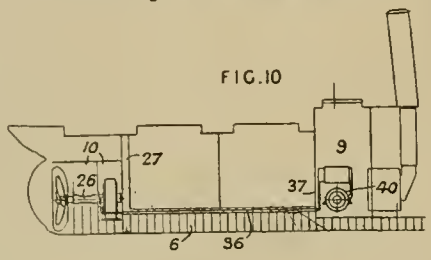


FIG. 10.



No. 171,755. Internal-Combustion Turbines.

Lawder, E. F., Holmehurst, Dynas Powis, Glamorgan, Wright, A. C., Ayot Place, Welwyn, Hertfordshire, and Burnip, W., 15, Ovington Terrace, Cardiff. May 17, 1921, No. 23898/20. [Class 110 (iii).]

In internal-combustion turbines, the combustion products are cooled by the admixture of water and additional air before passing to the turbine. The apparatus for this purpose comprises a choke tube flared at both ends, which ignites the fuel and over which cooling air flows. At the flared end the cooling air is discharged so as to mix with the combustion products and injected water in a heated disk which is inserted in the combustion chamber, the fuel tube being withdrawn a little way through a stuffing-box n; when the choke tube k is sufficiently heated, the plug o is withdrawn and the fuel tube returned.

No. 171,771. Ships.

Mercantile Engineers and Founders Limited, and Anderson, J., 227, St. Vincent Street, Glasgow. August 20, 1920, No. 24212. [Classes 7 (ii) and 114.]

Driving arrangements for screw propellers.—Comprises a forward and reverse gear-box for motor boats driven by internal-combustion engines in which the layshaft of the gear-box forms a continuation of the engine camshaft and in which four gear wheels are provided. The camshaft e is driven by gears m, n from the engine shaft c, and has a sprocket p which is connected by a chain r with a sprocket q freely mounted on the propeller shaft u. For forward driving, the portion w of a double clutch, which is slidably mounted on but keyed to the shaft u, is slidden into engagement with the element s, and so directly couples the shafts. For reverse driving, the portion v of the clutch is slidden into engagement with the element t on the sprocket q, the drive thus passing from the shaft c through the gears m, n, sprockets p, q, and chain r, to the shaft u. The clutch members may be of the expanding, plate, or disk types. The thrust collar 7 takes against the thrust-block z or the boss 8.

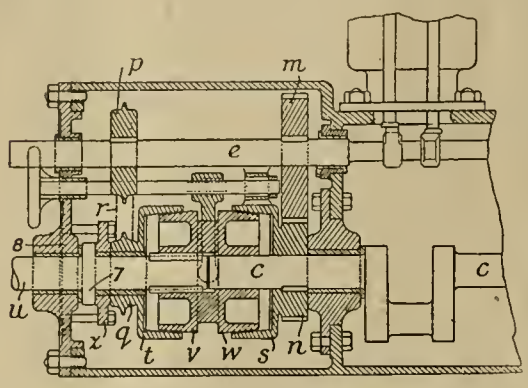


FIG. 1.

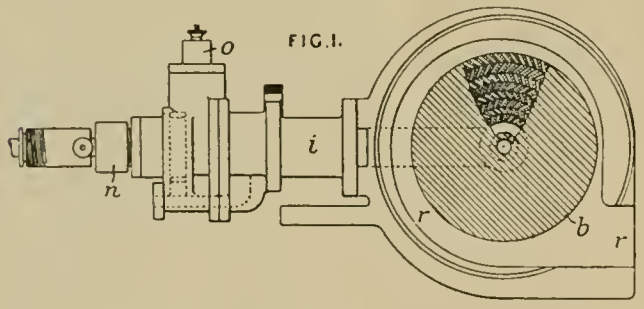
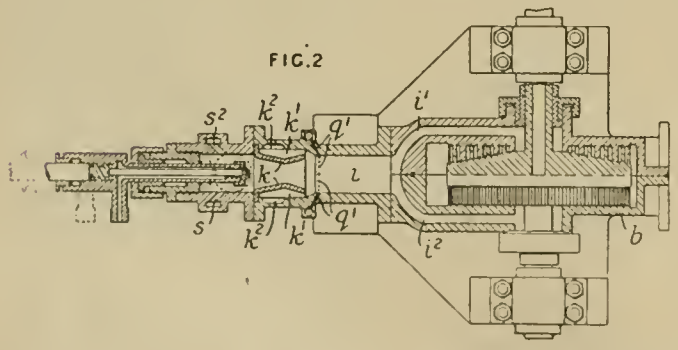


FIG. 2.



mixing chamber. Fuel issuing in a jet from a valve-controlled nozzle in a fuel supply tube mixes with combustion air supplied through parts s^2 and is fired by impinging on a heated choke tube k flared at both ends. The combustion products are cooled by injection of water through ports q^1 into a mixing chamber i and by the admixture of additional air admitted through the passage k^2 and directed over the choke tubes k by helical fins k^1 to the mixing chamber i. The cooled mixture is then led by passages i^1, i^2 to a radial-flow turbine with a rotor bladed on both sides, and expands to the exhaust r. Ignition is started by a plug o with an electrically-

OFFICIAL NOTICES.

The Proprietors of Letters Patent No. 123,312, relating to
REGULATING DEVICE FOR INTERNAL COMBUSTION ENGINES,
desire to dispose of their Patent or to grant licences to interested parties with a view to the adequate working of the Patent in this country.

The Proprietors of Letters Patent No. 103,826, relating to
FUEL PUMPS OF INTERNAL COMBUSTION ENGINES,
desire to dispose of their Patent or to grant licences to interested parties on reasonable terms with a view to the adequate working of the Patent in this country.

The Proprietor of Letters Patent No. 11,483/10, relating to
MEANS FOR ADMITTING WATER TO THE COMBUSTION CHAMBERS OF EXPLOSION ENGINES,
desires to dispose of his Patent or to grant licences to interested parties on reasonable terms with a view to the adequate working of the Patent in this country.

Enquiries to be addressed to—
CRUIKSHANK & FAIRWEATHER,
65–68, Chancery Lane,
London, W.C.2.

The Proprietors of the Patent No. 100,221, for
IMPROVEMENTS IN PROPELLING APPARATUS FOR VESSELS,
are desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country.

All communications should be addressed in the first instance to—
HASELTINE, LAKE & Co. (Chartered Patent Agents),
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The Owners of British Patent No. 137,858, relating to
IMPROVED ARRANGEMENTS FOR OPENING AND CLOSING BULKHEAD DOORS AND THE LIKE ON SHIPS,
are desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above invention either by sale of the Patent rights or by granting licences to manufacture under royalty.

Enquiries to be addressed to—
Messrs. ABEL & IMRAY (Chartered Patent Agents),
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The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
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AUXILIARIES & REFRIGERATION — CARGO HANDLING APPLIANCES

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

Vol. XLV. No. 534. March, 1922.

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Mr. David Roberts, M.Inst.C.E., Cardiff, has been elected President of the South Wales Institute of Engineers. After completing his articles Mr. Roberts joined the staff of the Dowlais Iron Works, Cardiff, where he eventually became Chief Engineer. About 20 years ago he set up as a consultant, and has been associated with the development of many large iron and steel works in this country and abroad.

At the recent election of Master and Wardens of the Worshipful Company of Shipwrights, the following officers were elected:—The Hon. Sir Charles A. Parsons, K.C.B., F.R.S., Master; Sir Charles E. Ellis, G.B.E., K.C.B., Upper Warden; Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E., Second Warden; Sir Kenneth S. Anderson, Bart., K.C.M.G., Third Warden; Sir Eustace Tennyson d'Eyncourt, K.C.B., Chief Naval Constructor at the Admiralty, Fourth Warden. Mr. William Lionel Hichens (Cammell Laird & Co. Limited) has been admitted to the Court.

Captain John Pritchard, ex-Commodore of the Cunard fleet, passed away at Meols, Cheshire, recently. He was one of the most famous of Atlantic captains and master of the *Campania* when the first Marconi wireless apparatus was installed in her. As Captain of the *Caronia* he took soundings of the new Ambrose Channel at the entrance to New York Harbour. As Commander of the same vessel he distinguished himself by taking that great liner into the inner harbour at Alexandria, a feat which hitherto had been considered an impossibility by the port authorities. He was the first Captain of the *Mauretania*, and was in command of her when in September, 1909, she broke the world's record by maintaining an average speed of 26·06 knots.

Mr. Peter Sydie, Assistant Chief Draughtsman in the shipyard department of Workman, Clark & Co. Limited, has accepted the post of Chief Draughtsman at Cammell Laird's Birkenhead Works, where he will again be serving under his former chief, Mr. R. S. Johnson, late of Belfast. The staff have presented Mr. Sydie with a silver tea and coffee service at a function recently, at which Mr. W. T. Shott, Chief Draughtsman, presided. Congratulatory speeches were delivered by Mr. J. McIlvenna, Lloyd's surveyor, and representatives of several companies now building in Belfast, as well as representatives of various departments of Workman, Clark & Co. Mr. Sydie has been 17 years with the firm and his removal to the Mersey is much regretted by his colleagues.

The death occurred recently of Sir Francis Henry Barker, a director of Vickers Limited. Sir Francis was born at Smyrna in June, 1865, the second son of the late Alfred Barker, of Constantinople and Elmfield, Esher, and was educated privately and at Clifton College. He received his early business training in his father's bank in Constantinople, subsequently becoming Private and Confidential Secretary to Sir Edgar Vincent (the present Lord d'Abernon), at that time Director-General of the Imperial Ottoman Bank at Constantinople. During this period he travelled extensively in Syria and other parts of Asia Minor. In 1899 the Parsons' Foreign Patents Company Limited was formed to exploit on the Continent of Europe Sir Charles Parsons' patents for marine and land turbine work. Sir Francis Barker was appointed manager of this company, and as such was instrumental in forming subsidiary companies in various foreign countries and in establishing works under the Parsons' Patents for the manufacture of land and marine turbines in those countries. He maintained his association with the Parsons' Foreign Patents Company Limited to the end.

The death occurred last month of Sir George J. Carter, K.B.E., Managing Director of Cammell Laird & Co. Limited, Birkenhead. Sir George was born in 1860, and started his shipbuilding career at Portsmouth Dockyard. At 26 he became Assistant Manager of Sir W. G. Armstrong, Whitworth & Co.'s shipyard at Elswick-on-Tyne, being promoted to Shipyard Manager in 1894. He remained with the Elswick firm for nearly 26 years, during part of which he was also on the board of directors. It was while under Mr. Carter's management that the idea of carrying out naval construction lower down the Tyne at Walker was originated and developed, and on his shoulders rested the responsibility of planning and laying out the Armstrong Naval Yard at Walker-on-Tyne. In 1912 Mr. W. L. Hichens, Chairman, Cammell Laird & Co. Limited, invited Mr. Carter to become Managing Director at Birkenhead. In that year Mr. Carter severed his connection with Elswick and devoted his energies to the development of the Tranmere Bay shipyard. Sir George became President of the Shipbuilding Employers' Federation at a most critical period in the history of shipbuilding, and occupied the position from 1914-1919, the whole of the war period. He was Chairman of the Advisory Committee on Merchant Shipbuilding. Sir George's name figured in the first list of appointments to the Order of the British Empire. He was created Knight Commander of the Order in 1917.

EDITORIAL.

PROBLEMS OF DIESEL ENGINE DESIGN.

IN all phases of design work we are apt to regard certain ideas as being fundamental, and thus incapable of any drastic alteration. In practice we seek only to improve, on the application of these ideas to any particular example, never considering that the idea itself may be wrong. This is particularly the case with Diesel engine design, where, owing to the fact that the difficulties of the problems have been so emphasised, we can hardly conceive of any solution save along the lines which are now being laboriously followed. It is a very good antidote to this state of mind to come up against somebody like Mr. Belyavin, who, in his paper "Some Problems of Marine Engine Design," read before the North-East Coast Institution of Engineers and Shipbuilders, does not hesitate to deal harshly with generally accepted ideas—or prejudices, as he calls them—on the subject under review. It is true that his own horizon is bounded by his own solutions to the different problems which he discusses, and he is—if we may say so—just as intolerant with regard to the ideas of those who would go even further than himself. Nevertheless, we welcome his paper because originality of thought in marine engineering problems is always beneficial and, further, because it must serve to stimulate discussion on the admittedly difficult problems of Diesel engine design.

In this paper the author does not deal with the minor details of design, but considers those basic problems which govern the choice of the cycle of operations which shall be adopted in the design, and as a result of his investigations, he considers that the two-stroke cycle single-acting engine forms the most suitable type for marine propulsion. He admits, of course, that the four-stroke engine as now manufactured is both economical and reliable, but, in addition to these desirable qualities, we have to consider the questions of size, weight, initial cost and the cost of annual repairs, and it is on these counts that the two-stroke engine could be made a better commercial proposition than the four-stroke. One of the chief factors which has retarded the development of the two-stroke engine is the increased mean temperature in the cylinder which results in increased heat stresses in the various working parts. The higher mean temperature cannot be eliminated, but its effects can be largely minimised by a suitable design of cylinder head and liner. In this respect it is admitted that owing to the absence of valves—the two-stroke engine with valve scavenging is considered a failure—the cylinder head of the two-stroke engine can be so designed that the heat stresses are to a large extent eliminated, so that the effect of the higher mean temperature is, if anything, easier to deal with than the lower mean temperature in the four-stroke engine. With regard to the cylinder liner, there is little difference in the two engines, except that in the two-stroke engine, since the cylinder diameter is less for a given power than is the four-stroke engine, the thickness of the liner is also reduced, and so the effect of heat stress is less. These considerations lead the author to the conclusion that, with necessary care in design, "a two-stroke engine cylinder and cover can be made even more reliable than those of the four-stroke engine."

The next problem dealt with is that of the size and weight of the engine. Here the height and the width need not be discussed, as these are of secondary importance, but the length has a marked effect on the economy of the ship. The length of the engine depends largely upon the size of the crankshaft bearings, and Mr. Belyavin puts forward the opinion that in most marine engines the bearings are calculated upon "completely wrong principles." He suggests that instead of basing the design upon the maximum pressure per unit of projected area of the bearing, it would be sufficient to base it upon the mean pressure. A number of formulæ are put forward for calculating the size of the bearing in terms of the work done by friction, *i.e.*, in terms of the mean pressure on the bearings a considerably smaller bearing is obtained and, as a result, the distance between the centres of the cylinders can also be reduced. Again, the present design of the webs is shown to be lacking in accuracy, and an investigation is made of the strength of the webs in terms of the stress due to torsion bending and also to the effects of shrinking on the shaft. From these, dimensions are obtained which yield a web considerably smaller than that at present employed, so that taken in conjunction with the proposed reduction in dimensions of the bearings we have a crankshaft which is also considerably smaller than that usually accepted, and as a result of the adoption of this smaller crankshaft we get a smaller and, therefore, a lighter and a cheaper engine for a given power.

The above represents, in outline, the two chief problems discussed, and it will be agreed that even if it is impossible to go as far as Mr. Belyavin, a thorough investigation of the principles which he has advanced will be helpful in demonstrating the possibility of reducing the size and weight of the marine Diesel engine. But the two-stroke single-acting engine is only a step in the direction of obtaining a smaller and a lighter engine for a given power, and it might be urged that the double-acting engine, or its equivalent—the opposed-piston engine—is a step further in the right direction. It is to be regretted, therefore, that the author saw fit to decry these endeavours in his eagerness to justify the two-stroke engine. That the two-stroke engine can be made to form a highly satisfactory unit for marine purposes is not denied, but it is not improbable that other and better types may yet be evolved, and those firms who at great expenditure of money and of effort are endeavouring to bring forward new types should receive every encouragement from those who have the future of the industry at heart.

MARINE DIESEL ENGINE FLEXIBILITY.

THE desideratum of flexibility in the Diesel marine engine may be said to resolve itself into the functions of obtaining a sufficiently low speed of revolution, and ease in starting and reversing.

In his paper on this subject, read before a meeting of the North-East Coast Institution of Engineers and Shipbuilders recently, Mr. W. S. Burn, M.Sc., pointed out that it is much more difficult to obtain a high degree of variation of load and revolution simultaneously than variation of load at constant speed, and it may be said that the marine Diesel engine requires the highest degree of flexibility of any present-day Diesel unit. The direct-driven Diesel locomotive can be considered an engine of the future. It may generally be stated that the lowest reliable speed of revolution at which the engine should be capable of running continuously is about 30 per cent. of the normal, and in practice most modern marine Diesel engines can accomplish this.

As the load or turning moment in a marine engine driving a propeller varies as the square of the revolution, or the power as the cube of the revolutions, at low speeds the loads are very small and only comparatively minute quantities of oil require to be injected. The problem of efficient injection at these low speeds is very acute, and special means to reduce the valve lift and duration of injection are very desirable.

It has been seen that the temperature due to compression is dependent with a given engine on the speed of revolution and to a less extent on the load; therefore, although there is little difficulty in obtaining the ignition temperature at light loads at normal speed, the difficulty becomes increasingly great in the marine engine when low speed is accompanied by a yet smaller load. The difficulty of obtaining efficient ignition and combustion is therefore obviously very much

accentuated in all respects in the case of the marine Diesel engine, and the special devices for securing the above are imperative.

Although maximum economy is always desirable at all speeds, the real index of flexibility in a Diesel marine engine at the present day is the ratio of $\frac{\text{highest speed}}{\text{lowest speed}}$ between which speed the engine will work with unfailing regularity, and also the ease and certainty of starting and reversing. In addition, Diesel engines for tug boats must be capable of being started gradually and able to run with full load at reduced speeds.

With regard to the lowest speed of revolution, the Diesel engine is more dependent upon the flywheel to overcome the idle strokes or part of a stroke than is the steam engine. A four-cylinder two-stroke engine is analogous with the compound steam engine, although the back pressure during the exhausting stroke in a steam engine is only a few pounds, whilst with the Diesel engine it increases up to the compression pressure of 500 lb. per square inch. In the case of the marine steam engine the speed is generally lowered by decreasing the steam pressure with a constant cut-off, but in the case of the Diesel engine the maximum pressure is practically constant and the period of combustion reduced, thus tending to increase the ratio of maximum to mean load, and making a still more uneven turning movement at low speeds.

As the momentum of a flywheel becomes very small with low speeds, a fair-sized flywheel is essential or the rotation of the engine becomes perceptibly jerky. The size of the flywheel required will depend on the number of cylinders, whether two-stroke or four-stroke, and on the compression pressure adopted, the four-cylinder two-stroke being equivalent in this direction to the eight-cylinder four-stroke.

One can now understand how the low-compression four-cylinder Doxford engine runs so smoothly at low speeds with a comparatively small flywheel. Marine engines designed to run at very low speeds should certainly have relatively large flywheels.

THE ARRANGEMENT OF MACHINERY.

WHEN planning the general arrangement of the machinery for a vessel, it is essential that great care and attention be given to making all parts accessible to the engineers operating the machinery. For overhauling the main propelling engines, if of the reciprocating type, it is very necessary to provide sufficient space on the top platform for working at the cylinder covers and also for withdrawing the pistons and rods. With turbine machinery, it is necessary to provide ample head room for lifting the turbine covers and rotors, to enable thorough inspection of those parts to be made, and in order to carry out any repairs necessary to the blading. To facilitate overhauling the turbines, it is good practice to arrange all pipe connections under the main horizontal flange in order to avoid the breaking of joints when lifting the turbine cover. In fixing the position of various auxiliaries throughout the engine room, those necessary for the propulsion of the vessel should receive special attention. It is important that they should be arranged so that they are within easy reach of the starting platform, and sufficient space should be allowed to enable necessary adjustments to be carried out readily while the ship is under way. The piping to these parts should be arranged so that the minimum of disturbance will be produced when overhauling any parts of those engines. To the boiler room equipment it is also of importance for the designer to pay close attention, as this part of the installation is often considered of relatively small importance, with the result that indifferent arrangements are produced which cause worry and annoyance to the engineers who have to work the machinery. It is desirable to have boiler mountings clear of all obstructions and easily got at; this is of especial importance with the main stop valves, which may have to be shut off suddenly in emergency, owing to the bursting of a steam pipe or for some other reason. The gauge-glass cocks and connections to the boiler should always be within easy reach of the boiler attendants, and means should be provided whereby these may be shut off at a distance from the gauge glass in the event of its bursting. In arranging the various pipes and connections throughout the vessel it is useful to have the suction and discharge pipes to all distribution boxes clearly marked, so as to guide the engineer in charge as to which valves should be opened or closed in order to obtain the desired object. All pipe leads should be arranged with the object that if one gives trouble through leaky joints or other causes, it can be readily removed or repaired without having to disturb other types adjacent; this is important with types subject to pressure. Pipes in groups are better arranged to run in one direction, either fore and aft or across the ship; interlacing pipes are a source of trouble when being fitted, and in the event of alterations being made or repairs effected considerable difficulty may be met with if the pipes are running in different directions. All the pipes underneath the main platforms are better arranged with the larger pipes near the tank tops and the smaller ones above. When fixing positions of the various suction and discharge valves on the ship-side it is desirable that these be placed in convenient and accessible positions; and in cases in which the connections are underneath the floor-plate level extended spindles with hand wheels above the platform should be fitted for operating these valves. Care should be taken that in no place are these connections fitted on the flat of the ship's bottom, but well round on the bilge, so that in the event of the ship becoming stuck on a sand or mud bank the apertures will not be choked and rendered useless. A point of considerable importance in machinery arrangements, and one which does not always receive the attention it deserves, is the arrangement of ladders and gratings through the engine and boiler rooms. This item makes up a small part of the total cost of the installation, and a little attention devoted in this direction, with facilities for getting at the various gear without trouble, means much to the engineers in charge of the machinery.

ENGAGEMENTS FOR MARCH.

Greenock Association of Engineers and Shipbuilders.—Meeting in the Watt Memorial, Dalrymple Street, Greenock, at 7.45 p.m.—Tuesday, March 7. Experiments on turbine nozzles. "Losses in Nozzles of Rectangular Section," by D. S. Anderson, B.Sc. (Holder of Greenock Research Scholarship).—Tuesday, March 14, visit to works of Babcock & Wilcox, Renfrew. Train leaves Gourock at 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland.—Special general meeting in Rankine Hall, 39, Elmbank Crescent, Glasgow, at 7.30 p.m., on Tuesday, March 7. Discussion on the following papers: "The Economic Proportion of Cargo Ships." by W. G. Cleghorn, B.Sc.; "Analysis of Propeller Performance," by Campbell Macmillan, B.Sc.; "The Design of Screw Propellers and the Analysis of Trial Results," by W. J. Duncan, B.Sc.

Institute of Metals.—Annual general meeting, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., on Wednesday and Thursday, March 8 and 9, at 10 a.m. each day. On Wednesday, March 8, at 7.30 for 8 p.m., the annual dinner takes place at the Trocadero Restaurant, Piccadilly Circus, London, W.

Institute of Marine Engineers.—Meetings at the Institute, the Minories, Tower Hill, London, E., at 6.30 p.m.—Tuesday, March 7, "On the Trail in Mexico," by C. Williamson Milne, with lantern views. Ladies' night.—Tuesday, March 14. "The Still System of Internal-Combustion Engine for Marine Propulsion," by F. L. Martineau.—Tuesday, March 21, "Animal Life at Sea, including all Living Things generally seen, with Notes on Flight," by Sir D. Wilson-Barker, with lantern views. Ladies' night.—Tuesday, March 28, "Petroleum and Lubrication," by E. A. Evans.—Tuesday, April 4, "The Depths of the Sea," by Capt. Alfred Carpenter, D.S.O., R.N. Ladies' night.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications

Le Danube International. December, 1921. Journal de la Commission Internationale du Danube. Budapest: Fo-Utca 1. 9 in. × 12 in. 27 pages. Price 1 fr.

Willing's Press Guide, 1922. London: James Willing Ltd., 30, King Street, Covent Garden, W.C.2. $5\frac{5}{8}$ in. × $8\frac{3}{4}$ in. × $\frac{7}{8}$ in. 505 pages. Price 2s. 6d.

Following the precedent of former years, the forty-ninth annual edition has been carefully revised. Its particular advantage is that it occupies very little space on the desk, and is very handy for reference.

Munro's Marine Engineers' Annual Pocket Log and Diary, 1922. Compiled and arranged by James K. Munro. Glasgow: James Munro & Co. Limited. 5 in. × $7\frac{1}{4}$ in. × $\frac{5}{8}$ in. 324 pages. Price 2s. net.

A record of progress and events in connection with marine engineering. Besides embodying the tables usually found in publications of this type, many useful formulæ and rules are given, together with interesting and instructive articles and reference matter which is often required by engineers.

"Mechanical World" Electrical Pocket Book, 1922. London: Emmott & Co. Limited, 20, Bedford Street, Strand, W.C.2. Manchester: 65, King Street. $4\frac{1}{8}$ in. × $6\frac{3}{8}$ in. × $\frac{1}{2}$ in. 393 pp. Price 2s. net.

The new issue has been enlarged and its scope has been extended to include a section on power station construction and operation. The chapter on switchgear and switchboards has been re-written, and there is a new section dealing with electric hoists.

Questions and Answers relating to Diesel, Semi-Diesel and other Internal-Combustion Engines, Air Compressors, &c. By John Lamb, M.I.Mar.E. London: Charles Griffin & Co. Limited, Exeter Street, Strand, W.C.2. $5\frac{3}{8}$ in. × 4 in. × $\frac{5}{8}$ in. 209 pp. Price 5s.

The publication of the author's book, "The Running and Maintenance of the Marine Diesel Engine," brought so many interesting inquiries that he found himself compiling a series of questions and answers on the subject. From this point the author proceeded to develop this useful little pocket-book to be of assistance especially to those preparing for the Board of Trade Examination.

Mechanical World Year Book, 1922. Manchester: Emmott & Co. Limited, "Mechanical World" Office, 65, King Street. London: 20, Bedford Street, Strand, W.C.2. $4\frac{1}{8}$ in. × $6\frac{3}{8}$ in. × 1 in. 348 pages + 267 advts. Price 2s. 6d. net.

This popular reference book has been enlarged by the addition of 20 pages. An important new section on pipes and tubes contains a concise collection of data on pipes of cast iron, wrought iron, steel and copper, with many tables giving dimensions, particulars of flanged bends and tees, expansion bends, &c. The boiler construction section has been re-written and new matter introduced. Many other revisions have been effected and a number of new illustrations introduced.

Handbook for Ironfounders. London: The Locomotive Publishing Co. Ltd., 3, Amen Corner, E.C.4, for the Frodair Iron and Steel Co. Ltd., Fenchurch House, E.C.3. 5 in. × $7\frac{1}{2}$ in. × $\frac{1}{4}$ in. 122 pages.

We had occasion in our last issue to draw attention to the lack of accurate knowledge concerning pig iron and iron castings generally. A wise and judicious selection of pig iron for mixing together goes a long way towards securing and guaranteeing the ideal casting. Every foundryman knows this, and so it is becoming the alpha and omega of laboratory and foundry practice alike. The intention of this "Handbook for Ironfounders" is not to upset accepted theories and practices, but rather to draw freely upon all available information and experience with a view to assisting the foundryman in the issues which are all-important to him.

Real Mathematics. By Ernest G. Beck. London: Henry Frowde and Hodder & Stoughton, *The Lancet* Building, 112, Bedford Street, Strand, W.C 2. $5\frac{1}{4}$ in. × $7\frac{1}{2}$ in. × $1\frac{3}{8}$ in. 306 pp. and 103 illustrations. Price 15s. net.

There must be something radically wrong with mathematics as taught in schools and technical colleges when, on all sides, we find writers endeavouring to devise new methods of teaching the subject. Perhaps it is the intellect of the average engineer which is at fault, for these new methods are generally devised either with the object of assisting the engineer to comprehend the intricacies of the subject or else to eliminate these intricacies and present an attenuated syllabus containing only such mathematics as are employed in elementary engineering science. The book which lies before us, however, is a welcome change from those which have recently been published. The author has indeed felt it necessary to write a book "intended mainly for practical engineers," but it has been written as an aid to the study and comprehension of mathematics as generally understood and not as a substitute for other text-books on the subject. And to that extent it should fulfil a very useful purpose. Too many young engineers become thoroughly disheartened at the very outset of their studies because they fail to grasp the true significance of the x's and the y's, and the $\frac{dy}{dx}$'s, nor are they able to visualise the various mathematical processes which they are called upon to perform. The author has endeavoured to surmount this difficulty by giving a material reality to the different processes involved in algebraic calculation. It is difficult to say what success would follow the application of these methods to a study of a recognised text-book on mathematics; in fact we are inclined to imagine that the average engineering student—who seldom has much time at his disposal—may find the reading of this book rather wearying. But if the author, who is himself a teacher, could persuade the teachers of mathematics in our technical schools to adopt his methods, he would, we believe, go far towards making the subject better understood than it is at the present time. This book should certainly be closely studied by them.

TRADE PUBLICATIONS.

Electric Overhead Travelling Cranes.—John M. Henderson & Co., King's Works, Aberdeen, have issued an illustrated catalogue, No. 40-2E, on electric overhead travelling cranes which they design and manufacture in addition to other transportation machinery. This catalogue is printed in four languages and the illustrations show overhead cranes of various types and with lifting capacities from 3 to 75 tons, already installed in works.

ENGINEERING AND CONSTRUCTIONAL NOTES.

Shell Taps for Ballast Tanks—Arrangement for Tank Filling and Tank Drain Bolt—Wedge for securing Hatch Tarpaulins—Indicating Deck Box for Watertight Doors and Valves.

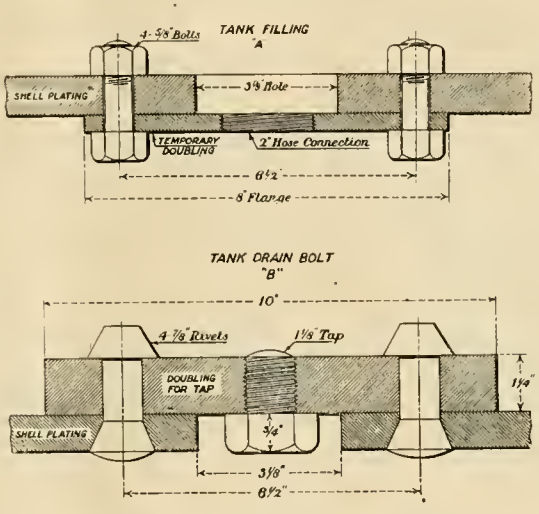
Many shipbuilders fill the ballast tanks when testing after construction through a hose connection in bottom shell plating.

It is the common practice of shipowners to require drain holes in the bottom of their vessel's ballast tanks to drain same when ship is dry docked.

A hole is tapped through the shell plating and a brass tap or plug is screwed in; this tap should not project below the surface of shell plating in order to prevent its being damaged should the vessel ground.

The illustration shows on "A" the temporary doubling in position to take the hose conection for testing. This doubling is bolted through the shell plating with four $\frac{5}{8}$-in. diam. bolts, and these same bolt-holes serve to take the rivets to connect a doubling on inside later. This doubling is screwed to take a $1\frac{1}{8}$ in. diam. brass tap as illustrated on section "B."

With this arrangement the head of the tap does not project beyond the thickness of the shell plating and is thus protected against damage.



Arrangement for Tank Filling and Drain Bolt to Tanks fitted to same Hole in Shell Plate.

Wedge for securing Hatch Tarpaulins.

The wedge illustrated has been designed for securing hatch tarpaulins without the aid of wood wedges. It can be used in association with the ordinary hatch cleats or it may be adopted in place of them.

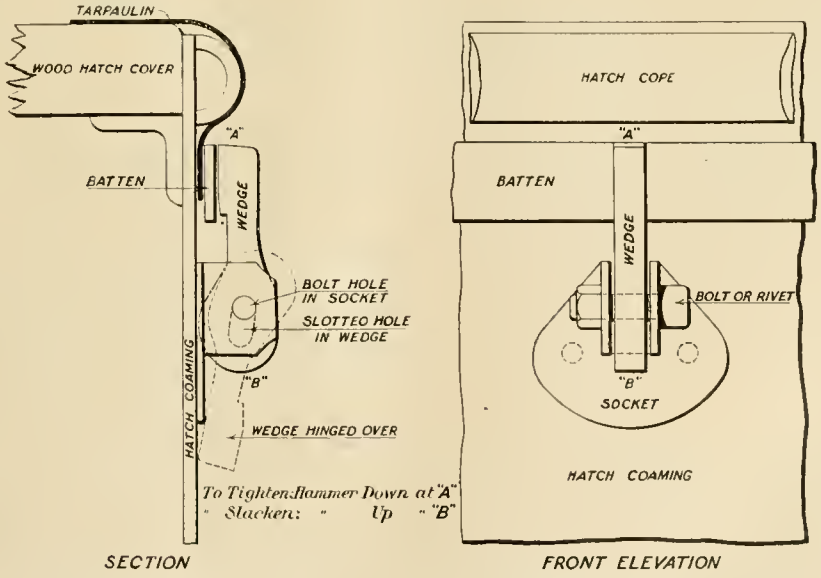
If used in association with the cleats, the wedges would be fitted every 6 ft. to 8 ft. and take the place of the nearest cleat to that position; for example, say, in a hatch 24 ft. × 16 ft., two wedges would be fitted on each side and end. Should the cleats be dispensed with then the wedges will be placed 2 ft. to 3 ft. apart as required for cleat spacing, according to the position of the hatch.

The cleat can either be forged or stamped, and either a rivet or a bolt can be fitted through the socket for it to swing on. In the socket the hole is round, but through the wedge an oblong hole is made to give the required travel to the wedge up or down, to slacken or tighten it.

When it is desired to tighten the wedge, it is hammered down at "A" to slacken it, hammered up at "B" from the underside, or the batten can be hammered up. The bottom socket can be constructed of a $2\frac{1}{2}$ in. × $2\frac{1}{2}$ in. angle formed into a shoe, or preferably it can be cast, which in practice is likely to be less expensive. This socket is connected to the coaming plate by two rivets. When the wedge is not operating, it may be swung over and lie below the socket (as shown dotted on section). Should there not be sufficient depth of coaming to allow this, or if there are steam pipes, a horizontal bulb angle stiffener, or other obstructions, then the wedge may be hammered down after the tarpaulin has been removed, and keep the hatch batten tight against the coaming.

From the shipowner's standpoint, this style of securing tarpaulins will be cheaper than using the wood wedges, because being made of steel they will last the life of the ship. Moreover, the cost of upkeep for wooden wedges is saved, and the steel ones are always in place ready for action. To the shipbuilder, this system will incur a small increase in cost; but it will be infinitesimal on the cost of a vessel. The increased cost will be the wedge and the bolt or rivet it swings on, for the bottom socket may be purchased as cheaply as the cleat, and the rivet attachment of either to the hatch coaming is similar. It will be observed that the top edge of the wedge forms the bearing surface against the hatch batten, therefore the harder the wedge is hammered down the more tightly will the tarpaulin be held, also the wedge will secure three tarpaulins as easily as one.

Wood wedges are continually being lost and are not in their place when required; therefore the steel wedge is more efficient than the old system, and any system that abolishes wood wedges is worthy of careful consideration.



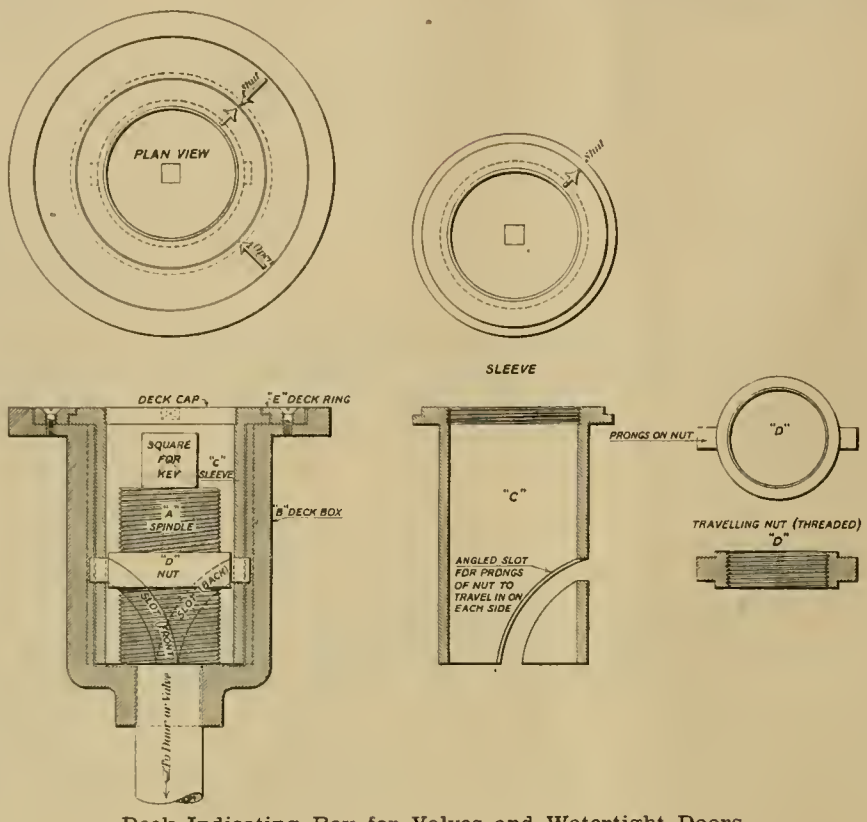
Section and Elevation of arrangement for securing Hatch Tarpaulins without Wood Wedges.

Indicating Deck Box for W.T. Doors and Valves.

The illustration overleaf shows an ingenious device which has been lately adopted in some vessels to enable anyone on the

deck at any time to know whether the watertight door or valve below is open or shut.

The arrangement is as follows :—" A " is a spindle operating the opening or shutting. " B " is a brass deck box in which is placed a brass sleeve " C," and this sleeve has a slot cut out of it on each side as shown. A nut " D " having prongs on each side travels up and down the spindle " A," the prongs fitting into the slots on sleeve " C," and also into the vertical slots on each side of deck box, the latter keeping the nut from travelling round with the spindle. The circular motion is imparted to the sleeve " C " by the nut " D," which travels vertically up and down the spindle " A " the prongs passing through the slots each side of the sleeve give it the circular motion. The spindle is screwed to suit the required number of turns necessary to open or shut the door or valve. For example, a door requiring two and a-half turns of spindle to operate it would have spindle " A " and nut " D " screwed to suit about 1 in. pitch, while a door requiring 12 turns of spindle to operate it would have spindle and nut screwed about six threads to the inch. The deck ring " E " has engraved on it " Open " and " Shut," these words being placed at a distance apart equivalent to the travel of the sleeve. An arrow mark is engraved on the flange of the sleeve. When the spindle is turned to open or shut the door or valve the sleeve turns horizontally an equivalent distance to the spindle nut's vertical travel, so that the distance between the arrow mark on the deck flange of sleeve and the open and shut marks on the deck ring indicate at all times the true position of the door or valve.



Deck Indicating Box for Valves and Watertight Doors.

DOCKYARD-BUILT MARINE ENGINES FOR THE ANGLO-SAXON PETROLEUM COMPANY.

The two interesting illustrations on page 106 show the main engines of the single-screw oil tanker *Nassa* being built on a fixed price contract at H.M. Dockyard, Devonport, for the Anglo-Saxon Petroleum Company Limited, London.

The *Nassa* was laid down on March 8, 1921, and has the following dimensions :—

Length, b.p.	417 ft.
Breadth, extreme	53 ft. 4 in.
Depth, moulded	31 ft.
Gross tonnage (about)	5,680.
U.D. "	5,263.
Net "	3,435.

The vessel is constructed on the Isherwood system of framing, and is to have a deadweight capacity of about 8,400 tons with a draught of 24 ft. 7½ in. and a speed of 11 knots. She has been designed for carrying oil in bulk in nine main tanks and five summer tanks. A 10-in. diam. double pipe line is installed so as to minimise the chances of mixing in the event of the vessel carrying a cargo of different kinds of oil. The cargo is worked by two Heywood-Tyler duplex pumps 14 in. × 12 in. × 14 in.

The propelling machinery consists of a single set of triple expansion engines having cylinders 27 in., 45 in. and 74 in. diam., with a stroke of 48 in., which are estimated to develop about 2,800 i.h.p. at 78-80 r.p.m. Steam is generated by three single-ended boilers, 15 ft. 6 in. diam. by 11 ft. 7½ in., fitted with Tracy purifiers. The boilers are arranged to burn either coal or oil fuel, the oil fuel system being of the Zulver-Smith type. The vessel carries about 1,140 tons of fuel, and has stowage for about 1,000 tons of water ballast.

The *Nassa*, which is a sister ship to the *Nobia*, building at Portsmouth Dockyard under the same contract, is expected to be completed in May next, which is 15 months after laying down the keel. Considering that the vessel is urgently needed this delivery cannot at all be considered as satisfactory, and if the dockyards intend to compete with private yards in the construction of merchant ships they will certainly have to do some speeding up for a vessel like the *Nassa* could, without any special effort, be completed in eight months by the majority of private builders.

In view of the remarks contained in the report of the Geddes Committee to the effect that an average of all the home dockyards shows that £3 is paid in wages for every £1 worth of material consumed in naval repairs and construction work, whereas in private yards the comparable figures on such work are only £1 10s. in wages for every £1 worth of material, it will be very difficult for the dockyards to put in a reasonable contract price for any merchant work unless the shipowner is prepared to meet an outrageous account for extras.

Apart from these questions, one is inclined to think that these vessels constructed in H.M. Dockyards will embody some good workmanship if it is on the standard of that of naval construction, and it will be rather interesting to watch the behaviour of the two ships.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.—II.

By E. V. Telfer, B.Sc.

The second quantity contributing to the transverse metacentric height is the distance of the centre of buoyancy above keel. This distance we call b in our previous article, and is indicated in Fig. 4. This figure gives the usual curve of waterplane areas and it is well known that the centroid of this figure coincides in relative position with the actual centre of buoyancy of the ship. If the curve of waterplane areas were a known function of the draught, then its centroid could be directly determined by ordinary integration. In actual ships we are unable to adopt such procedure, and are restricted to the use of approximate formulæ whose basis we endeavour to make as fundamental as possible.

In this connection, in Fig. 4 let α and $\hat{c}$ be the waterplane

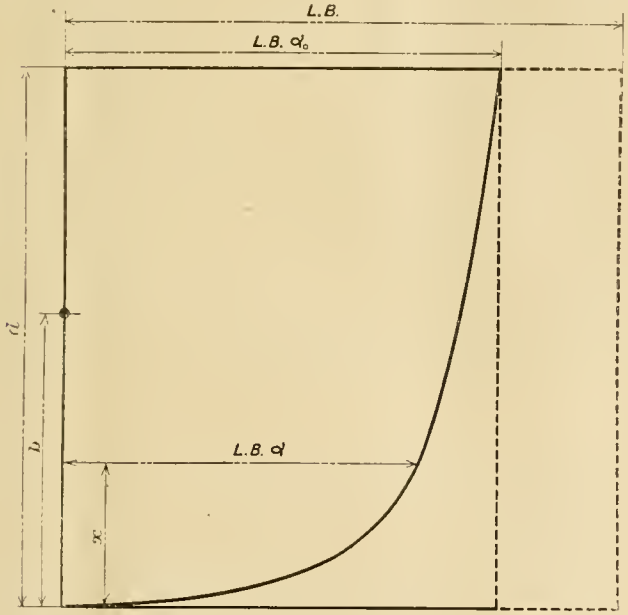


Fig. 4.

area and block coefficients respectively at draught x; let the corresponding coefficients at the load draught d be α_o and $\hat{c}_o$. Consider now how α_o, $\hat{c}_o$, and d may serve as parameters for the determination of the form of the waterplane area curve, *i.e.*, consider the validity of the equation $\alpha_x = f(\alpha_o, \hat{c}_o, d, x)$. A superficial examination shows that $\frac{\hat{c}_o}{\alpha_o}$ measures the fullness of the curve; and provided that the nature of the curve be regular, it will be possible to make use of the above relation modified preferably in the form $\alpha_x = f\left(\frac{\hat{c}_o}{\alpha_o} d, x\right)$.

From first principles we may now write

$$b = \frac{\text{L.B.} \int_o^d x \cdot \alpha \, dx}{\text{L.B.} \int_o^d \alpha \, dx} = \frac{\int_o^d x \cdot f\left(\frac{\hat{c}_o}{\alpha_o} d, x\right) dx}{\int_o^d f\left(\frac{\hat{c}_o}{\alpha_o}, d, x\right) dx}$$

and this we can assume, when the actual integration has been performed, reduces to $b = f'\left(\frac{\hat{c}_o}{\alpha_o}\right) \cdot d$.

As is evident from the above procedure, the position of b is independent of L and B since variations in these merely produce similar forms once α and $\hat{c}$ are fixed.

Let us now consider some selected shape of waterplane area curve in order to arrive at a definite value for $f'\left(\frac{\hat{c}_o}{\alpha_o}\right)$. This selecting of shape is akin to replacing the actual curve by one whose mathematical form is known and is an artifice which has been used ever since naval architecture became a science.

Let $$\frac{\alpha}{\alpha_o} = \left(\frac{x}{d}\right)^n$$

where n is to be determined, but whose value will generally be less than unity.

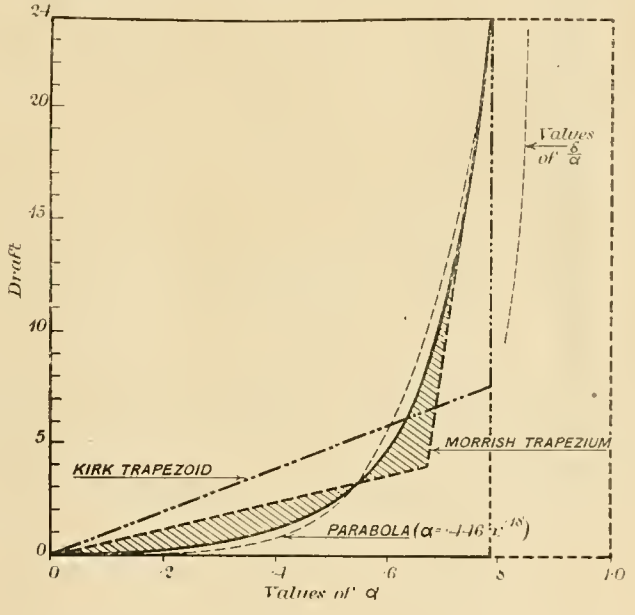


Fig. 5.

Now as $\hat{c}_o$ is the mean value of α over the range o to d, *i.e.*, as—

$$\hat{c}_o = \frac{1}{d} \cdot \int_o^d \alpha \, dx$$

we have

$$\hat{c}_o = \frac{1}{d} \cdot \int_o^d \alpha_o \cdot \left(\frac{x}{d}\right)^n dx = \frac{\alpha_o}{d^{n+1}} \cdot \int_o^d x^n dx = \frac{\alpha_o}{d^{n+1}} \cdot \left[\frac{x^{n+1}}{n+1}\right]_o^d$$

$$= \frac{\alpha_o}{n+1}$$

from which we have, therefore,

$$n = \frac{\alpha_o}{\hat{c}_o} - 1.$$

We can now proceed to the determination of b.

$$b = \frac{\frac{\alpha_o}{d^n} \cdot \int_o^d x^n x \, dx}{\int_o^d \alpha \, dx}$$

which, when the integration is performed, reduces to

$$b = \frac{\alpha_o}{\delta_o} \times \frac{d}{n+2};$$

this in turn reduces, after substitution for n to

$$b = \left(\frac{1}{1+\frac{\delta}{\alpha}}\right) d.$$

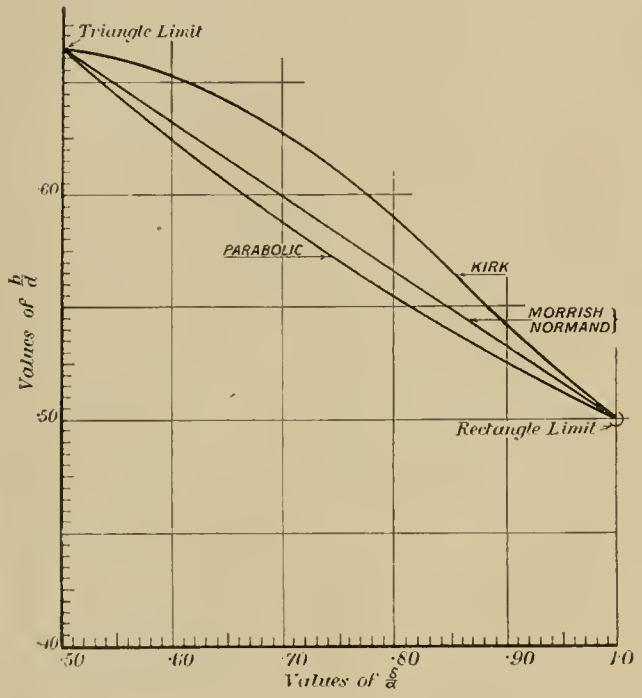


Fig. 6.

To show the validity of the above assumption, there is drawn in Fig. 5 the actual waterplane area curve of an intermediate passenger liner of α_o value = ·79, and δ_o = ·668, load draught 24 ft.

From the above, since $n = \frac{\alpha_o}{\delta_o} - 1$, we have

$$n = \frac{\cdot 79}{\cdot 668} - 1 = 1\cdot 18 - 1 = \cdot 18;$$

also since $$\alpha = \frac{\alpha_o}{d^n} x^n$$

we have $$\alpha = \frac{\cdot 79}{24^{\cdot 18}} . x^{\cdot 18} = \cdot 446 . x^{\cdot 18}.$$

This function (shown dotted) is also plotted in Fig. 5. It is there seen that a very close agreement in shape is given, and hence it is reasonable to assume that at least in this type the corresponding formula for the position of centre of buoyancy will give accurate results. From general considerations it is easily seen that since the assumed and real curves intersect and since above the point of intersection the assumed curve has a higher position of centroid than the actual, and below this point the assumed has a lower position of centroid than the actual, owing to this contrary effect, the precise position of the centroids for the complete figures will be almost identical. As calculated from the ship's lines by the Simpson method, the position of centre of buoyancy is 13·1 ft. above keel; by the Tchebycheff method 13·05 ft. By this formula it is

$$24 \left(\frac{1}{1+\frac{\cdot 668}{\cdot 79}}\right) = \frac{24}{1\cdot 846} = 13\cdot 0 \text{ ft.}$$

Thus the error in this approximate method is — ·77 per cent. or — ·39 per cent., depending upon whether the Simpson or Tchebycheff calculation is taken as correct.

Consider now the value of this expression for b over a range of $\frac{\delta}{\alpha}$ values. Two limits are at once evident: first, the lower limit when the waterplane area curve is triangular, $\frac{\delta}{\alpha} = \cdot 50$ and b obviously equals $\frac{2}{3} d$; second, the upper limit when the curve is rectangular, $\frac{\delta}{\alpha} = 1\cdot 0$ and b obviously equals $\frac{d}{2}$. Both these results are correctly given by the formula, and in Fig. 6 values of b are plotted on a base of $\frac{\delta}{\alpha}$ between the above limits. The resulting curve is seen to be slightly convex to the base line.

Consider next the substitution for the waterplane area curve of a trapezium of equivalent area. This is, of course, the underlying idea in the well-known Morrish formula. It will be profitable to go through the derivation of this formula in a somewhat different manner from that usually given.

Instead of the usual curve of actual waterplane areas, the curve of waterplane area coefficients may be used. This is done in Fig. 7. The problem is now to obtain the equivalent trapezium. If the mean ordinates of the α curve be obtained on, and drawn parallel to, the respective bases of load waterplane coefficient and load draught, their point of intersection P when joined to the extremes K and Q of these respective bases gives the required trapezium. This is easily shown as follows:—The mean ordinate with respect to the draught is obviously $\hat{c}$ the block coefficient; and $d \cdot \delta$ is the displacement of a basis vessel of length and breadth unity. Similarly, with respect to the load waterplane coefficient, the mean ordinate equals $\frac{d \cdot \hat{c}}{\alpha} = d \cdot \frac{\delta}{\alpha}$ and is generally known as the Rankine mean depth and is designated in the fig. as d_m. Since these mean rectangles overlap and are of equal area, it follows that the non-overlapping portions are also of equal area, and hence also half these portions. If, therefore, the triangle P R Q be taken away from the upper mean rectangle and the triangle P S K be added to it, obviously the area of the trapezium Q P K T is equal in area to the mean rectangle, and hence is the trapezium required. The further assumption in the Morrish analysis is that the centroid of the trapezium coincides very nearly with that of the actual curvilinear figure. This centroid

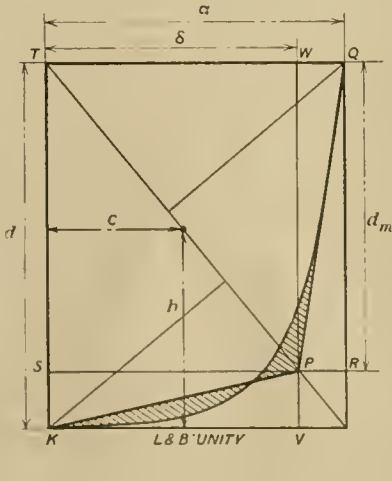


Fig. 7.

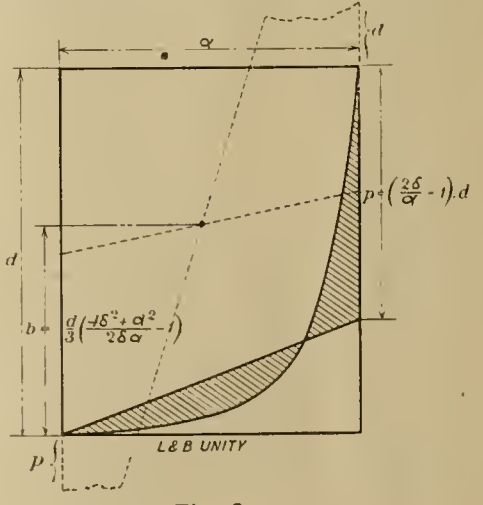


Fig. 8.

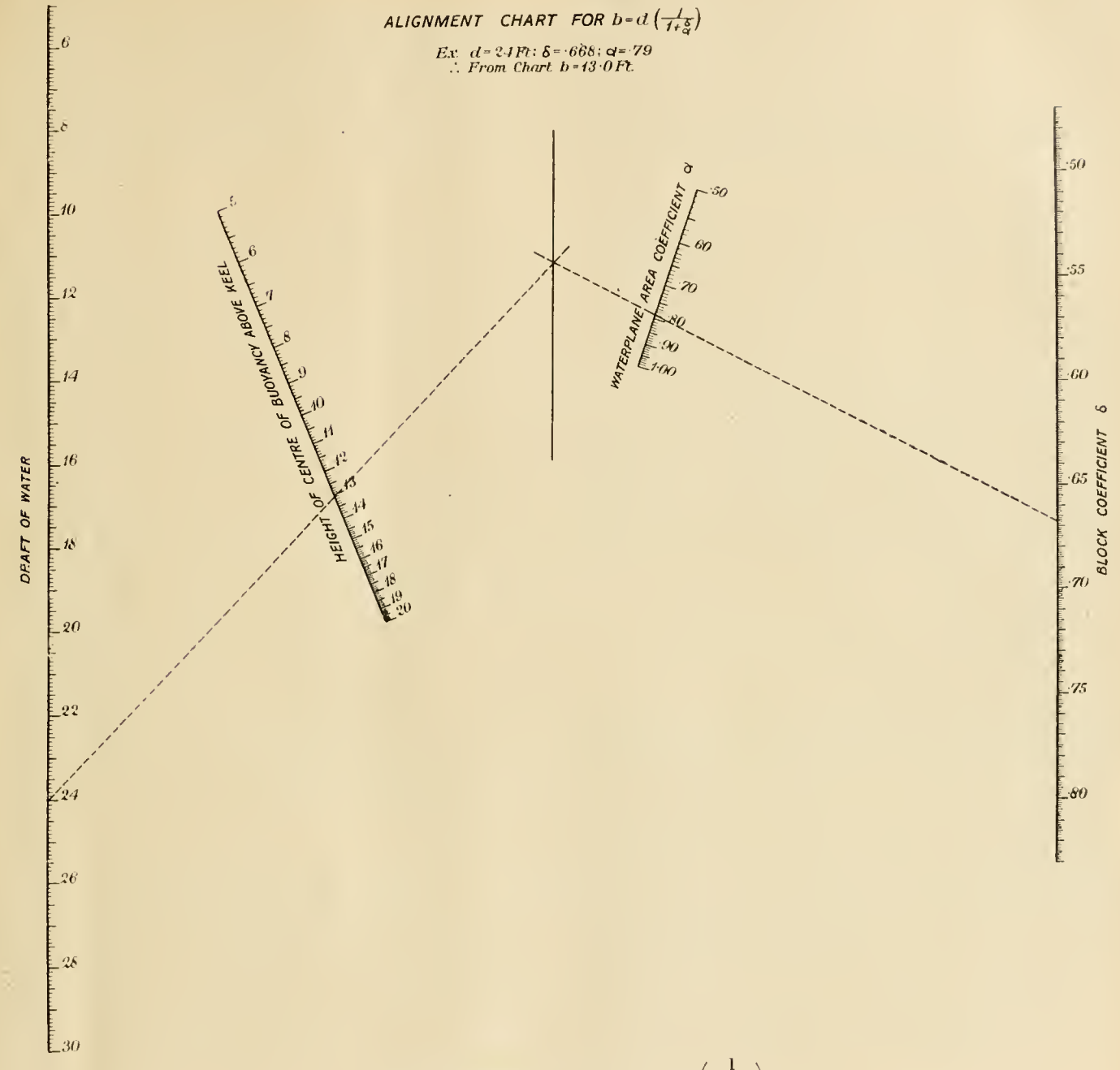

ALIGNMENT CHART FOR $b = d\left(\frac{1}{1+\frac{\delta}{\alpha}}\right)$
Ex. $d = 24$ Ft; $\delta = \cdot668$; $\alpha = \cdot79$
∴ From Chart $b = 13\cdot0$ Ft.
DRAFT OF WATER
HEIGHT OF CENTRE OF BUOYANCY ABOVE KEEL
WATERPLANE AREA COEFFICIENT α
BLOCK COEFFICIENT δ

Fig. 9.—Alignment Chart for $b = d\left(\frac{1}{1+\frac{\delta}{\alpha}}\right)$.

is most easily found by obtaining the shift of the centroid of the mean rectangle $d \times \hat{c}$ due to the movement of the centroid of triangle P V K to the centroid of the triangle Q W P, *i.e.*, the movement of an area $\left(\frac{\alpha - \hat{c}}{2}\right) d \cdot \frac{\hat{c}}{\alpha}$ through a distance $\frac{2d}{3}$ *i.e.*, a moment of $\frac{d^2}{3} \cdot (\alpha - \hat{c}) \cdot \frac{\hat{c}}{\alpha}$. Hence the movement of the centroid of trapezium above half draught is

$$\frac{\frac{d^2}{3}(\alpha - \hat{c}) \cdot \frac{\hat{c}}{\alpha}}{d\delta} = \frac{d}{3} \cdot \frac{\alpha - \hat{c}}{\alpha}$$

$$\therefore \quad b = \frac{d}{2} + \frac{d}{3} \cdot \frac{\alpha - \delta}{\alpha} = d\left(\frac{1}{2} + \frac{1}{3} - \frac{1}{3}\frac{\delta}{\alpha}\right)$$

$$= d\left(\frac{5}{6} - \frac{1}{3}\frac{\delta}{\alpha}\right),$$

and this result is, of course, the Morrish formula referred to the keel instead of the load waterplane.

In Fig. 5 is also shown the equivalent trapezium, and it is evident that in this case the centroid of the trapezium will be higher than the actual centre of buoyancy, owing to the considerable loss of moment in the bottom segment. This is verified by actual calculation: we have, as before, $d = 24$; $\frac{\delta}{\alpha} = \cdot846$.

$$\therefore \quad b = 24\left(\cdot833 - \frac{\cdot846}{3}\right) = 24 \times \cdot551$$

$$= 13\cdot23 \text{ ft.}$$

Here the error is ·13 ft. or roughly 1 per cent. when referred to the Simpson; when referred to the Tchebycheff the error is ·18 ft. or 1·37 per cent. This percentage is referred to the actual value of b. In Morrish's paper (I.N.A., 1892) this percentage is referred to the vessel's mean draught, and very small percentage errors are met with over a wide variation

of form. Of these two alternatives it is, however, reasonable to assume that the former is more correct in principle.

In Fig. 6 the value of b is plotted to a base of $\frac{\hat{r}}{\alpha}$ in a similar manner to the first case. Here again the limiting conditions are satisfied and the resulting locus is a straight line between these two points, thus being continually higher than the parabolic curve, but only differing from it by a maximum amount of under 2 per cent.

This formula was also given by Normand, in his "Formules approximatives," at least 20 years before Morrish published it. Normand, from quasi-general reasoning, showed that b should vary as some function of $\frac{V}{A}$, and by examining a large number of ships he found this to be as above. This basis and the large number of examples given by Morrish are a strong recommendation for the use of this formula.

There is yet a further assumption which it may be well to investigate, that of the substitution of an equivalent trapezoid. This is an artifice analogous to that used by Kirk and others in the deduction of formulæ for wetted surface. A consideration of Fig. 8 shows that whilst the assumption is reasonable for vessels having considerable rise of floor, it cannot be expected to be so reasonable for vessels of ordinary section (*see* Fig. 2). Without going through the mathematical analysis in detail, it can easily be shown that p in Fig. 8, in order to give the equivalent area, must equal $d \cdot \left(2\frac{\delta}{\alpha} - 1\right)$; further, by simply taking moments the value of b can be shown to equal

$$\frac{d}{3}\left(\frac{4\hat{r}^2 + \alpha^2}{2\,\hat{r}\,\alpha} - 1\right).$$

(The position of the centroid may also be found by the usual geometric method; this is shown dotted in Fig. 8.) This formula also satisfies the triangular, and rectangular limits, and the locus of b as given by it is shown with the previous loci to a base of $\frac{\hat{r}}{\alpha}$ in Fig. 3. It is very evident that the assumption involved in the method is an extreme one, and perhaps its only direct use is to illlustrate the probable range of accuracy of the two previous formulæ.

These formulæ are seen to produce results which, in spite of the diverse nature of the assumptions, give very close agreement. Of the two formulæ, it is suggested that the parabolic is the one to be preferred. It is quite as easy to calculate as the Morrish; it is based upon a curve which is continuous, and which agrees closer with the actual than does the Morrish trapezium. This parabolic formula is made the basis of the alignment chart shown in Fig. 9; the following explanation of its construction will be useful. The formula $b = \frac{d}{1 + \frac{\delta}{\alpha}}$ may be written as $b = \frac{d}{f\left(\frac{\hat{r}}{\alpha}\right)}$ where $f\left(\frac{\hat{r}}{\alpha}\right) = 1 + \frac{\hat{r}}{\alpha}$.

The left-hand portion of the chart, therefore, represents the relation $b = \frac{d}{f\left(\frac{\hat{r}}{\alpha}\right)}$; and by deducting unity from the values on the $f\left(\frac{\hat{r}}{\alpha}\right)$ support (not graduated in fig.), the relation $1 + \frac{\hat{r}}{\alpha}$ may be represented by the right-hand portion. The example mentioned previously in connection with this formula is shown on the chart.

Further reference to the chart and formula brings out the fact, that even considerable change in the value of α does not produce appreciable change in the value of b. In the example given in Part I of this article, it was shown that by filling out the waterplane from ·79 to ·83, the metacentric radius was increased from 10·1 to 11·1 ft. The effect of this filling out upon the centre of buoyancy is merely to raise it from 13·0 ft. to 13·3 ft. above the keel. It follows from this that the value of b is much less sensitive to variation of α than the value of r. As further increase in α for a given $\hat{r}$ will tend to increase the position of the centre of gravity of hull, it is probable that any small increase in b due to α will be counteracted by this increase in the position of the centre of gravity, *i.e.*, the value of a (*i.e.*, $B_o G$) will be more or less constant. This point will be further investigated in the next instalment of the article.

Erratum.—In Part I of this article (January, page 6) in table I the Normand inertia coefficient was printed ·008 + ·0745; this should read ·008 + ·0745 α^2.

SOCIETY OF CONSULTING MARINE ENGINEERS AND SHIP SURVEYORS.

ANNUAL DINNER.

The Annual Dinner of the Society of Consulting Marine Engineers and Ship Surveyors was held on February 23 at the Connaught Rooms. The Right Hon. Sir Henry E. Duke proposed the toast of the Society, and in reply, the chairman, Mr. George Humphreys, referred to the great depression through which the shipbuilding industry was passing, and stated that he, personally, hoped that it would last a little longer as by this means the industry would be quit of those adventurers and novices who had entered it during the boom, and they would then get back to the old-time shipowner who knew his business, which would be to the industry's benefit.

The Ex-President, Sir J. Fortescue Flannery, Bart., M.P., proposed the toast of "The Guests." Mr. Justice Hill, of the Admiralty, Probate and Divorce Division, in reply, stated that he not only dealt with collisions at sea, but also with conjugal collisions and errors in matrimonial navigation—in fact, he had one foot in the sea and the other in a sewer. He loved the seaman even when he lied, but detested the adulterer whether he spoke the truth or not.

Sir George Hunter, K.B.E., D.Sc., in reply to the toast of "The Kindred Institutions," spoke of the present period of difficulty for shipbuilders and the urgent need for a reduction in costs of construction and repairs. Shipbuilders were doing their best by eliminating profits and by persuading the men to help in the recovery by doing more work or accepting lower wages, or both. Unless this condition was attained the prosperity of the industry could not be restored. Sir George stated that he had not much faith in the statements which appeared in newspapers on labour unrest, and he was glad to say that there never was a time when there was a better feeling existing between the employers and the men than at present, and the employers intended to strive to maintain this good feeling and to get the men's assistance to restore the prosperity of the shipbuilding industry.

NEW MOTOR SHIP "DOMINION MILLER."

Built by William Doxford & Sons Ltd., Sunderland, for the Norfolk & North American Steam Shipping Co. Ltd. (Furness, Withy & Co. Ltd., Managers), and propelled by the Doxford Opposed-piston Type of Oil Engine.

Trials of the new motor ship *Dominion Miller* were run off the Tyne last month. This vessel, which is of the open shelter deck type, is the second motor vessel to be completed by Wm. Doxford & Sons Limited, Sunderland, and is for the Norfolk & N. American Steam Shipping Company Limited, of which Furness, Withy & Co. Limited, London, are the managers. The other motor ship was the *Yngaren*, which was the first to be fitted with the Doxford opposed-piston type of oil engine.

Dimensions.

The following are the dimensions of the *Dominion Miller* :—

Length	420 ft.
Breadth	54 ft.
Depth, moulded to upper deck	29 ft.
Deadweight	8,960 tons.
Draught	25 ft. 6 in.
Gross tonnage	5,489 tons.
Net tonnage	3,142 tons.

The tank capacities are as follows :—

Double bottom	1,299 tons.
Fore peak	127 ,,
After peak	105 ,,
	1,531 ,,
Deep tank forward of engine room	1,007 ,,
Deep tank aft of and extending into the engine room	943 ,,
Total	3,481 ,,

The double bottom tanks are arranged for carrying about 1,132 tons of oil fuel.

Steam Auxiliary Machinery.

A notable feature of this motor ship is that the whole of the deck and engine-room auxiliary machinery is steam-driven—there being 12 winches made by John Wigham, Hylton, a steam windlass made by Emerson, Walker & Thompson Bros. Limited, a steam steering gear (situated in the after deckhouse) of the Wilson Pirrie type manufactured by John Hastie & Co. and fitted with McTaggart Scott's telemotor gear. Each cargo winch works a five-ton derrick, there being four derricks to each mast and four derrick posts, two being fitted right aft and two amidships.

The captain's and officers' accommodation and two spare cabins are situated in the 'midship deckhouse; the engineers are berthed in houses at the sides of and at the after end of the engine casing, and the seamen and greasers are provided with cabins to hold two and four, at the aft end of the upper deck and in a deckhouse over. The vessel is lighted throughout with electric light and fitted with wireless telegraphy.

Propelling Machinery.

The propelling machinery consists of a single Doxford low-pressure oil engine, having four cylinders 22¾ in. diam., each with two opposed pistons and each piston having a stroke of 45½ in. The engine develops 3,000 i.h.p. at 77 r.p.m., and is similar to the unit fitted in the first motor vessel built by Doxford's, viz., the *Yngaren*. It is to be observed that the fitting of electric auxiliaries in the engine room, as in the *Yngaren*, is to be considered standard practice. The machinery fitted in the *Dominion Miller* was really the first set made, and steam auxiliaries were adopted in this case in order that attention might be concentrated on the main engines. The drive to the propeller shafting is taken through a Michell thrust block.

The steam for the auxiliaries, heating the main engine for starting, &c., is supplied by two Cochrane boilers each 16 ft. 6 in. high by 8 ft. diam. and 100 lb. pressure, which are situated at the forward end of the engine room, one on the port side and one on the starboard; the boilers are oil-fired, one having a Doxford and one a Todd burner.. The oil fuel unit, Weir's boiler feed pumps, &c., are also fitted against the forward engine-room bulkhead. The main fuel pumps, driven from the crankshaft at the after end of the main engine, inject the oil into the cylinders mechanically at a pressure of from 8,000 to 9,000 lb. per square inch.

Steam-driven auxiliary fuel pumps, for starting, are situated on the starboard side of the engine room near the centre of length of the main engines, *i.e.*, opposite the starting platform.

Arrangement of Machinery.

Commencing immediately aft of the donkey boiler on the port side are situated, respectively, the ballast pump, bilge pump, general service pump and transfer pumps (in duplicate) for the boiler fuel oil—all of Weir make—whilst over these are fitted the settling tanks, filters, &c. Between the foregoing and the main engine are the auxiliary air compressors (in duplicate). These are three-stage steam-driven compressors by Brotherhood, and each capable of delivering 250 cu. ft. of full air per minute to 750 lb. per square inch at 350 revolutions. The air is delivered to two "bottles" each containing about 100 cu. ft. at 700 lb. pressure for starting purposes. The bottles are fitted vertically against the after bulkhead on the starboard side, and it is reported that during the trip down the Wear to sea 16 starts were obtained from one bottle.

On the starboard side of the engine room are fitted the electric light set made by the Sunderland Forge & Engineering Company Limited, and main engine lubricating oil pumps and circulating water pumps for main engine pistons, water jackets, &c.—these pumps being of Weir make and in duplicate. There is also a centrifugal pump for circulating the auxiliary condenser, cooler for main engine circulating water, &c.

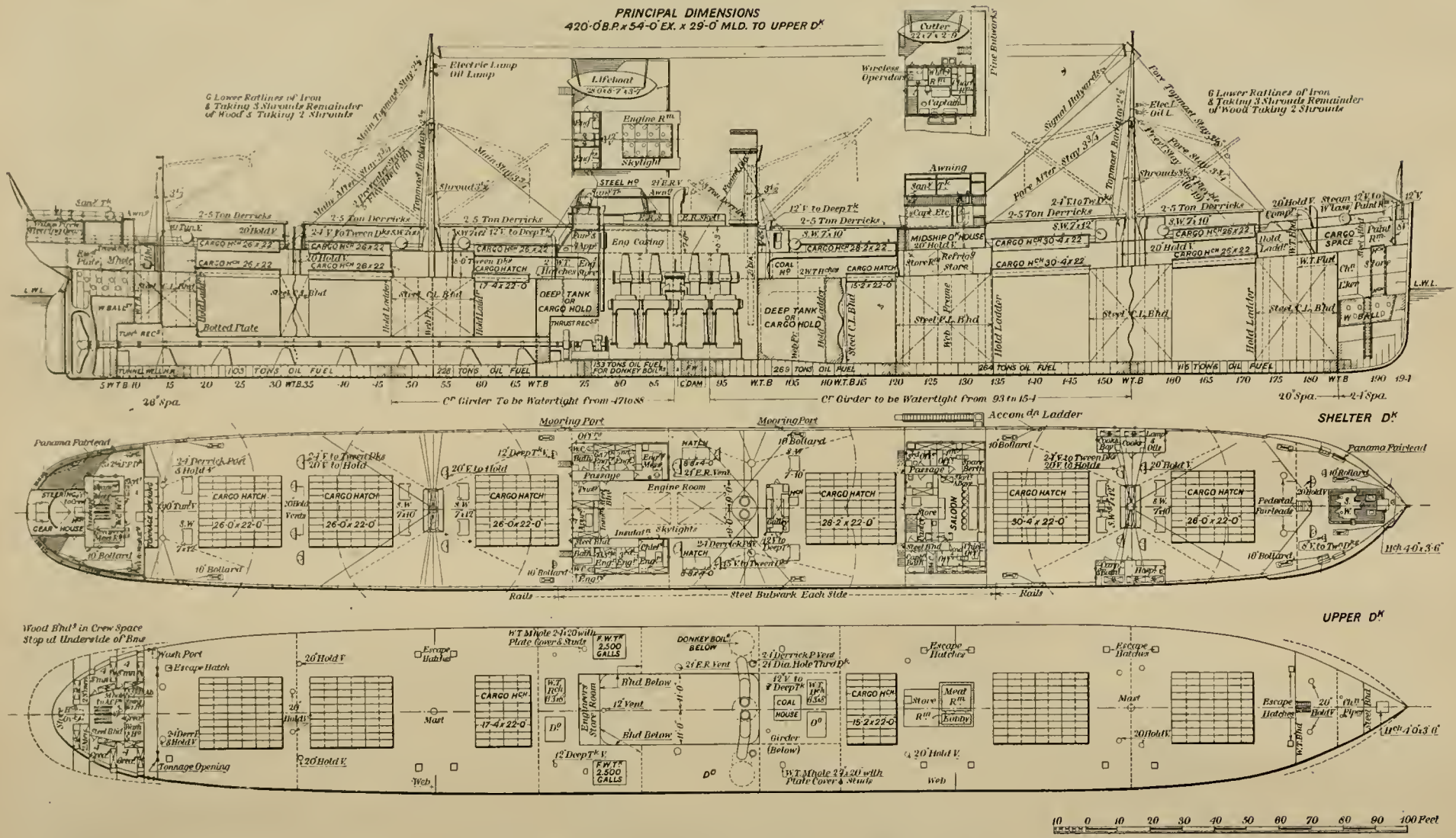
Trial Data.

The official trial trip was successfully run off the mouth of the Tyne on February 15, and it was observed when going down the Tyne (where the vessel proceeded for loading) to sea that the many orders transmitted from the bridge were quickly executed; at "slow ahead" or "slow astern," with engine revolutions at some 35 per minute, there was a complete absence of vibration or noise in the engine room. The starting air was then being used at about 500 lb. per square inch.

The vessel was partly loaded and drawing about 10 ft. forward and 19 ft. aft at the time of the trial trip, and the mean speed over the measured mile was 12·2 knots with engine revolutions 76 per minute.

The oil used was Anglo-American with a specific gravity of 0·89. During the whole of the trial the engine behaved splendidly with a complete absence of vibration or noise at all speeds, and immediately after the runs over the measured mile the vessel proceeded on her voyage to the River Plate.

It is anticipated that at a sea speed of 10–10½ knots and the engine developing about 2,500 i.h.p. the oil consumption will be 10-11 tons per day.



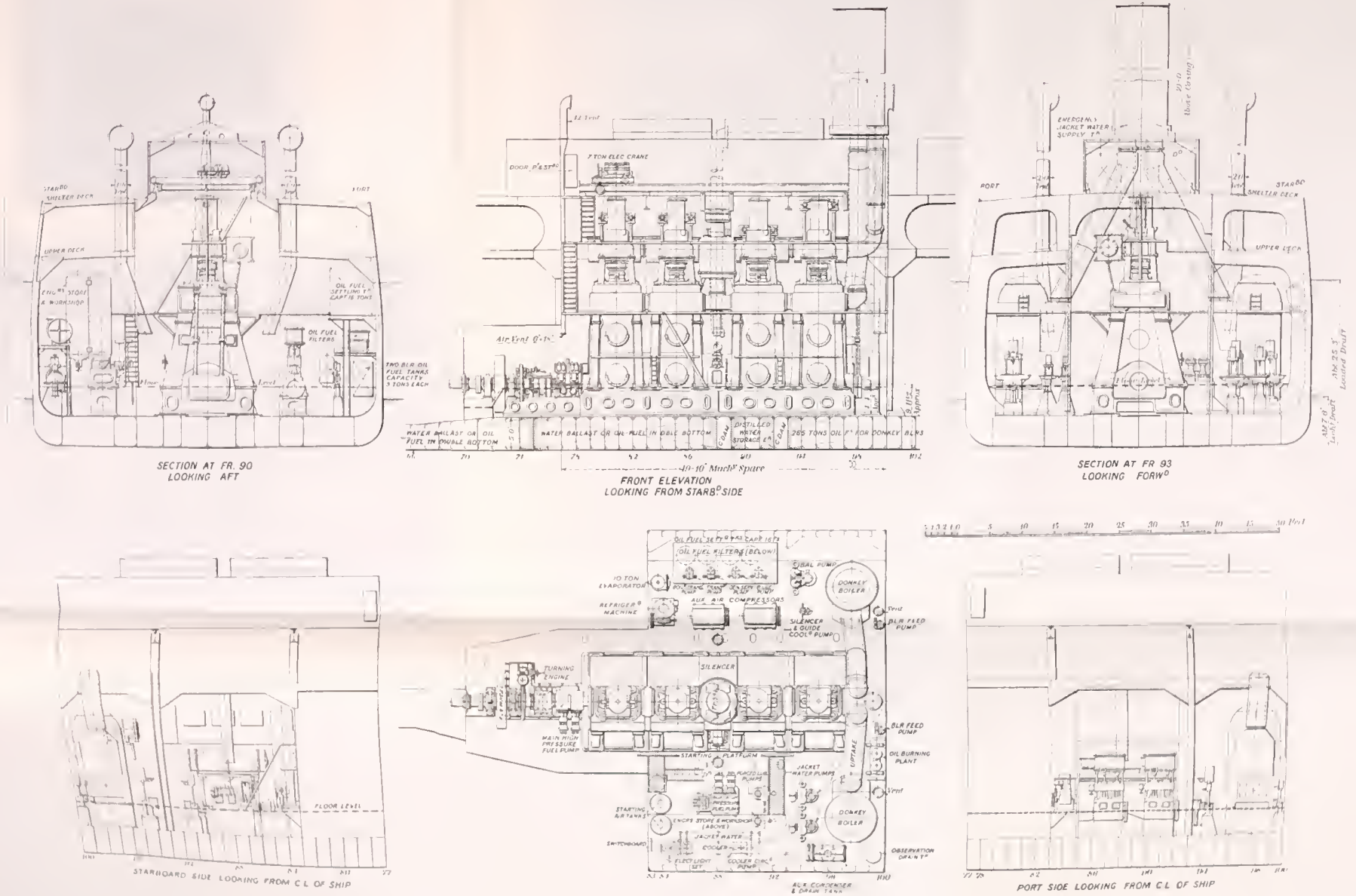
General Arrangement of New Motor Ship "Dominion Miller."

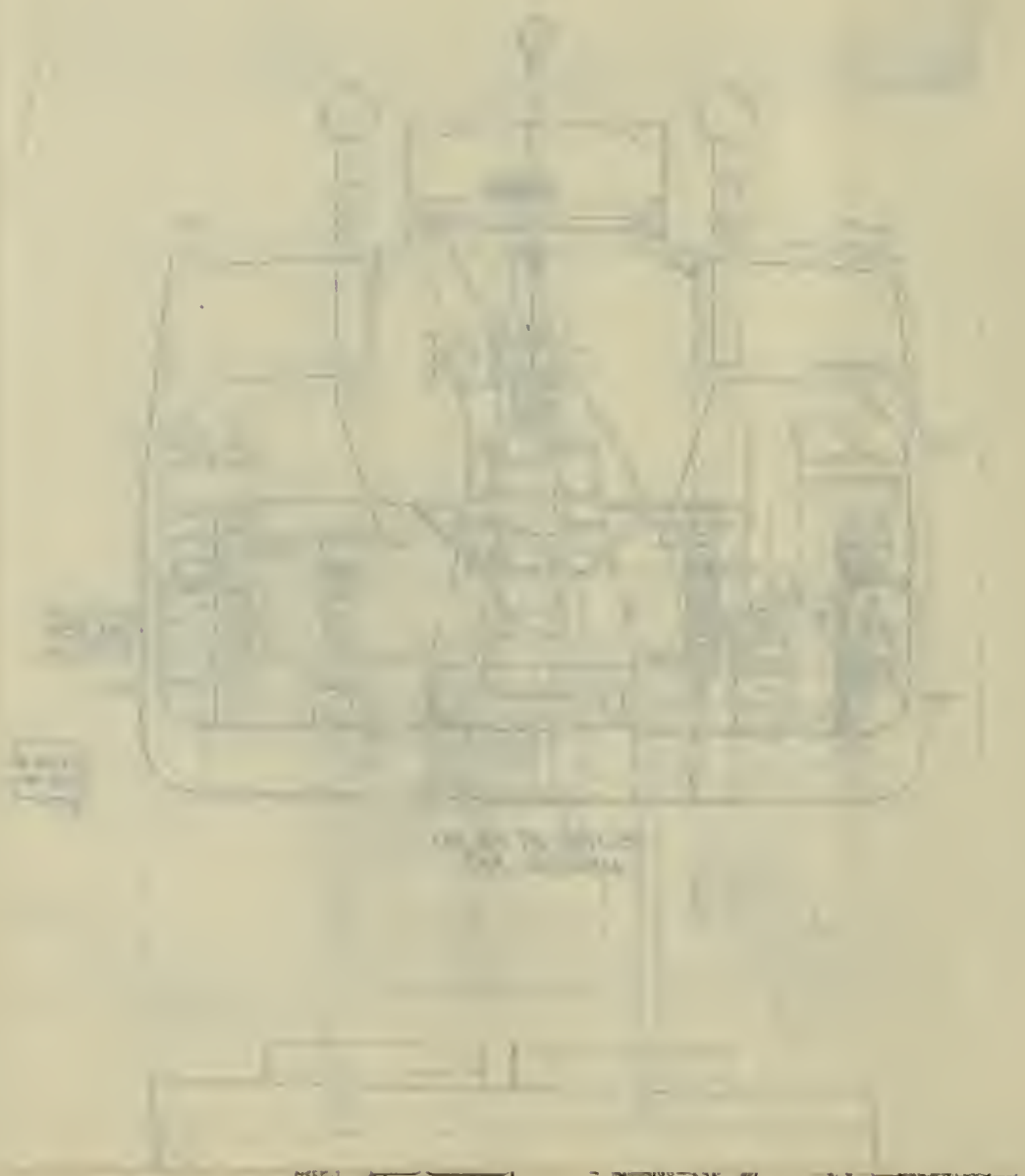
(Single-deck, shelter type; 8,960 tons on 25½' draught; 3,000 H.P.—12 knots.)

MOTOR SHIP "DOMINION MILLER."

Built by William Doxford & Sons Limited, Sunderland, for the Norfolk & North American Steam Shipping Co. (Furness, Withy & Co. Limited, Managers). Doxford Opposed-piston Oil Engines.

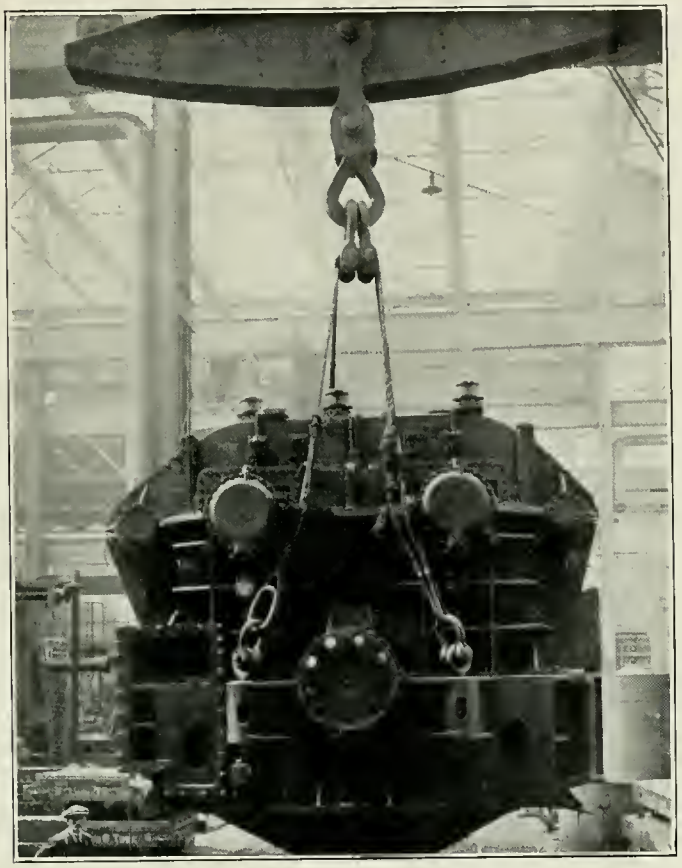
(General Arrangement of Machinery in Engine Room. See page 101.)


SECTION AT FR. 90
LOOKING AFT
FRONT ELEVATION
LOOKING FROM STARB° SIDE
SECTION AT FR 93
LOOKING FORW°
STARBOARD SIDE LOOKING FROM C.L. OF SHIP
PORT SIDE LOOKING FROM C.L. OF SHIP

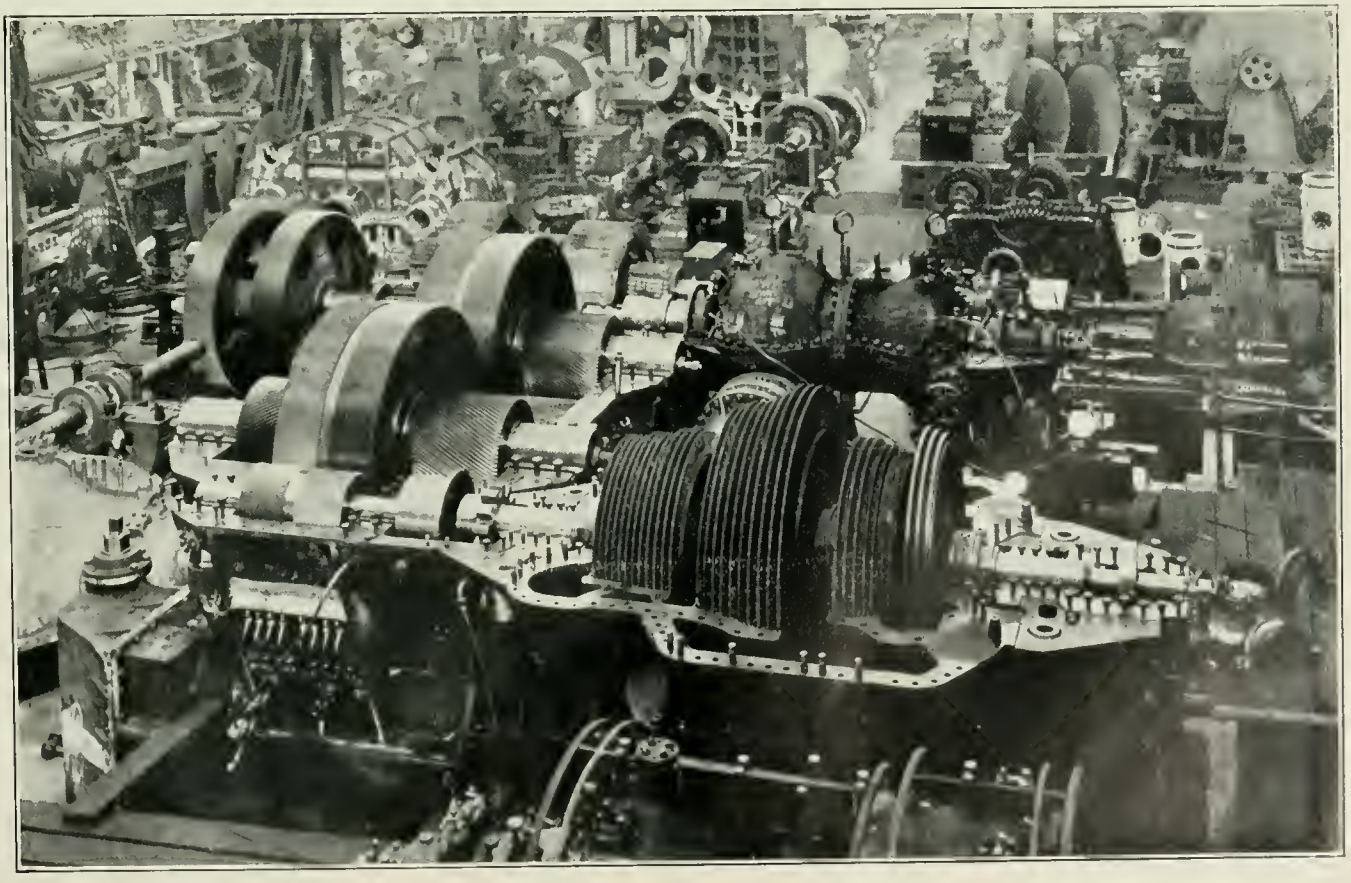


The Motor Passenger Liner "Domala."

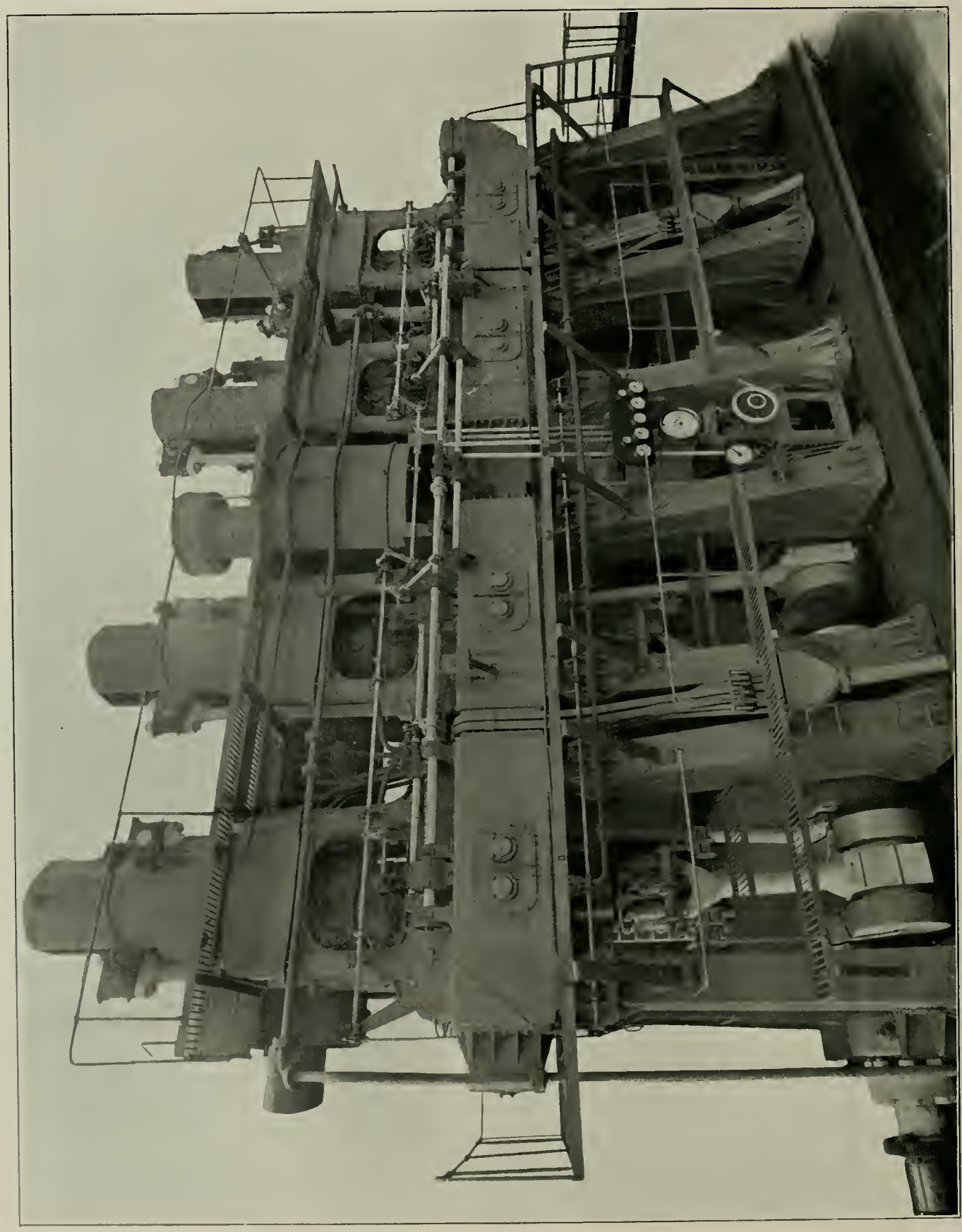
The maiden voyage from London to Bombay of the British India Company's 8,000-ton motor liner *Domala* has justified the expectation of her owners. She left London with passengers for Bombay on December 30 last and reached the latter port practically at the scheduled hour on January 27. The twin sets of Diesel, heavy oil, internal-combustion engines ran throughout the voyage with smoothness and economy, their daily consumption at 13½ knots being under 17 tons, or one-fourth only in weight of the coal equivalent. The vessel is scheduled to leave Karachi for the United Kingdom within the next few days, and her homeward performance will be watched with interest. The *Domala* is one of 20 similar vessels built or projected during the past nine years for the British India Company. Earlier vessels of her type have been fitted variously to run reciprocating engines with coal fuel, reciprocating engines with oil fuel, geared turbines with coal fuel and geared turbines with oil fuel. The adoption in the *Domala* of internal-combustion engines has established a basis for comparison of the relative efficiency, in sister ships, of five varying methods of propulsion, and the information obtainable should prove of considerable value in future marine engineering practice. The British India Company has five motor vessels now building, including one at Barclay, Curle & Co.'s yard, of the same tonnage and design as the *Domala*, and which will, like that vessel, be engined by the North British Diesel Works. We published drawings of the main engines of the *Domala* in last month's issue.



A Gear Case for the "Conte Rosso."



General View of the Starboard Engines of the "Conte Rosso," showing H.P. and L.P. Turbines and the Double-Reduction Gearing. (*See page* 123.)



The Doxford Opposed-piston Type of Oil Engine.

THE STILL ENGINE FOR MARINE PROPULSION.

Mr. Archibald Rennie gives particulars* of the Marine Type of Still Engine (two of which are to be installed in a New Holt Liner), designed and constructed by Scott's Shipbuilding & Engineering Co. Ltd., Greenock.

During the past few years many researches have been made which show that heavy-oil engines designed to operate on the Still system give a lower fuel consumption per brake horse-power, have a lighter weight per unit of power, and occupy less space than any other known type of heavy-oil engine. The fundamental principle is the recovery of heat fron the waste products of combustion, and the utilisation of that heat in the engine itself for the development of power. This heat is recovered and converted into power through the medium of steam. The transfer of heat from the waste gases to the steam generating system takes place in the combustion cylinder and in a regenerator and feed-water heater.

In this paper attention will be directed to an engine of the single-piston type which works on its combustion (or top) side upon the two-stroke port scavenging principle, and employs airless (solid) injection for the fuel oil; and on its steam (or bottom) side operates upon the single-acting principle, further economy being obtained by compounding the cylinders of one or more groups on the steam side. Both these functions occur once per revolution, the steam side being 180 deg. of crank angle behind the oil side, so that the engine is double-acting in its operation, witb this limitation, however, that the power developed on the steam side is considerably less than that developed on the oil side. Another important point of difference to be noted is that, whereas in all other oil engines of reasonably large power oil or water is circulated to the pistons for cooling purposes, in the Still engine this function is performed by the operating steam, which in any case is passing through the cylinder, and in keeping the piston cool the steam itself tends to become superheated, thus reacting beneficially on the efficiency of the steam cycle. Compared with other oil engines, it may be said of the Still engine that steam, generated from oil burned in the regenerator, displaces compressed air for starting and manœuvring purposes. When, however, these operations are completed, the Still engine presents this important advantage, that steam continues to be generated from the waste heat of combustion alone, and is utilised in the cylinders for the continuous production of power, thus adding energy without adding to the fuel cost.

In considering the construction of a full-size experimental unit for marine purposes, it was decided that the engine should be of such dimensions as would cover a range of power varying from about 700 to 7,000 b.h.p., with single or twin-screws, and a reasonable number of cylinders. Consideration of revolutions mean effective pressure, and other factors ultimately resulted in a cylinder of 22 in. diameter and 36 in. stroke being adopted as the most suitable. Such an engine, running at a speed of 120 r.p.m., was estimated to give a normal brake horse-power of 350 in one cylinder at maximum efficiency, and an overload of about 400 b.h.p. A single-cylinder two-stroke experimental engine of this size was, therefore, proceeded with, the crankshaft and bedplate being made of such dimensions as would be suitable for six cylinders of this size in line. The sectional end elevation of one line of cylinders is shown in Fig. 1 overleaf.

The combustion cylinder, which in its completed state may be said to consist of three parts, namely, the working liner, the outer mantle, and the scavenging and exhaust belt, is supported from the columns by four distance pieces through which large steel bolts are passed, having their upper ends secured to the mantle and their lower ends let into and secured to the upper part of the columns. These bolts take the combustion load, and transmit it through the columns to the bedplate. The steam and water jacket joints between the liner and mantle are made on the conical face and stuffing-box shown at X and Y, Fig. 1. The liner itself is only $\frac{5}{8}$ in. thick in the body. It is ribbed vertically, and its upper half is fitted with steel shrouds shrunk on, to give the necessary strength to resist the bursting pressure due to combustion. Incidentally these shrouds assist the convection currents within the jacket to a considerable extent. A sectional plan of the liner is shown in Fig. 2. The main idea underlying the design of the Still engine liner is the reduction of the temperature differences and consequent heat stresses between its inner and outer walls to the lowest possible minimum, and the provision of ample surface for the rapid transfer of heat to the jacket water. The steam cylinder is supported from the columns quite independently of the combustion cylinder, and has complete freedom for expansion. The cover is of deep formation, and is projected well into the cylinder, leaving only a small annulus with sufficient clearance for the piston skirt. The steam and exhaust valves, of which there are two and four respectively of simple piston type, are carried well into the cover head to reduce the steam clearance volume to a minimum, and are directly connected to their operators bolted on the cover flange. The combustion and steam cylinders are component parts of a whole, with a common piston, and where the barrels of the cylinders meet they are formed with a series of fingers, which mesh with each other and overlap for about 1 in., thereby providing ample guiding surface for the piston rings as they pass from one cylinder to the other. Oil for piston lubrication is introduced into the cylinder at three points in its circumference.

The piston is made in two parts, the head being spirally ribbed internally, as shown, to guide the flow of steam over the crown in as long a path as is reasonably possible. At the same time this formation provides the piston with some degree of flexibility, and allows it to adjust itself to temperature conditions without danger of fracturing the ribs. The piston-rod neck is pierced by six holes for the guidance of the steam to the piston head, and is enlarged in diameter at this part to maintain its strength. These holes convey the steam, during the admission period, into the cylinder by way of the ribbed space on the underside of the piston head, heating the steam and cooling the head in the process to the manifest advantage of both.

Valve-gear Operation (Oil and Steam).

The whole engine is symmetrical about its fore and aft centre-line in all essentials, so that it runs equally well ahead or astern at any load. The only valves in operation when running are the fuel-injection valve on the combustion side, and the steam and exhaust valves on the steam side. The former is worked automatically by the fuel-injection pressure, and the latter by a system of oil under pressure. The fuel-injection valve is spring loaded. It is centrally situated in the cylinder head, and carries relief valve and indicator connections in its outer casing. It sits in a conical seat formed on the upper projecting mouth of the combustion cylinder liner, and is secured to the top of the cylinder mantle through heavy springs, which allow of the valve adjusting itself to suit temperature conditions. These springs also allow the

* Abstract of Paper read by Mr. Archibald Rennie, on February 14, before the Institution of Engineers and Shipbuilders in Scotland.

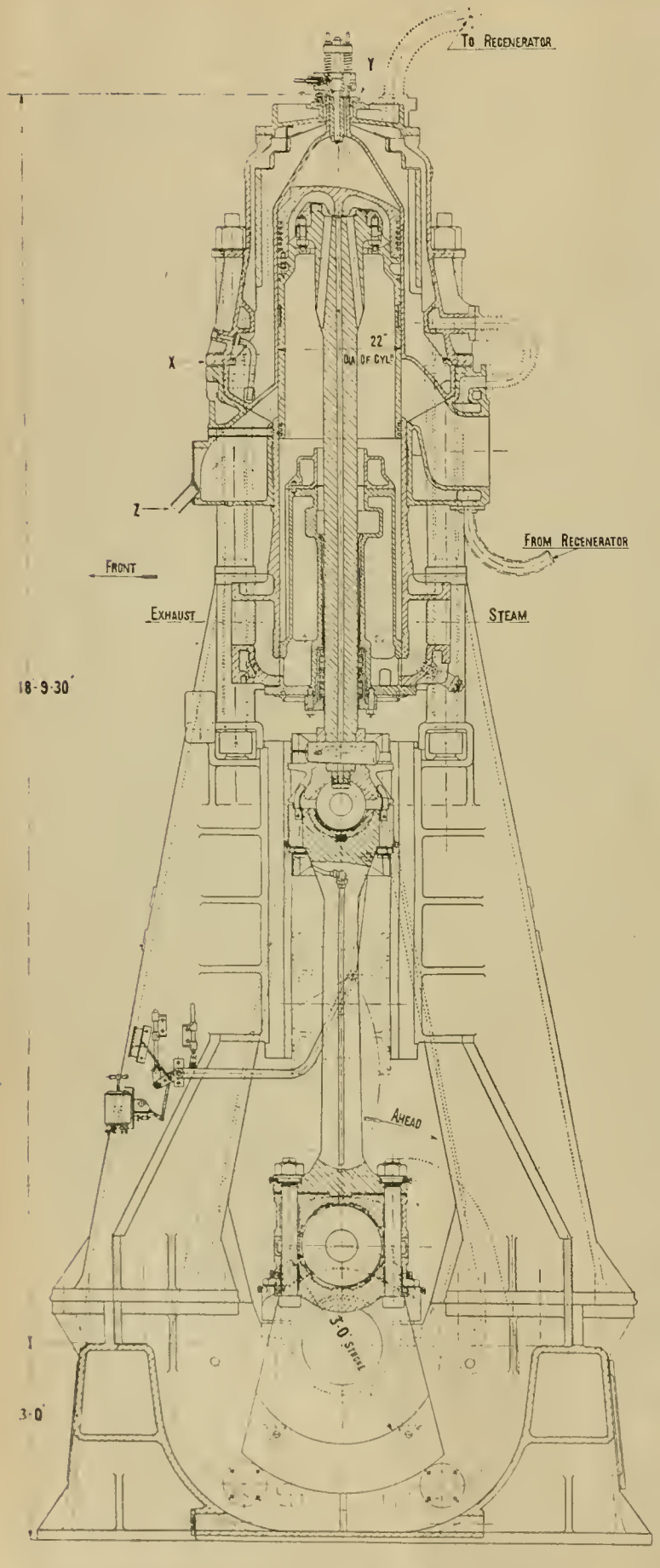


Fig. 1.—Sectional End View, "Still" Engine.

complete valve unit to act as a safety valve to the combustion side of the engine. The fuel-injection pump is fitted down at the crankshaft level, where it is worked direct by a cam from the shaft. The plunger is $1\frac{1}{4}$ in. in diameter and the stroke 1·3 in. The timing of the fuel injection is fixed by the cam, and the period of injection by the spill valve. This spill valve opens from the discharge chamber of the pump, and is worked by the same lever as actuates the pump plunger. Its function is to break the pressure of discharge at the end of the desired injection period and return the spilled oil to the suction again. The sudden and positive break in pressure allows the fuel valve to seat itself quickly, and prevents the formation of drips on the nose of the jet. The spill-valve action is such that increase of power is obtained by increasing the injection period, which is the ideal condition, and very difficult to attain with cam-operated valves. At normal load the fuel-injection pressure at the valve is about 6,000 lb. per sq. in. The jet found most suitable has one hole of $\frac{20}{1000}$ in. diameter in its centre, surrounded by a ring of eight holes, each of $\frac{24}{1000}$ in. diameter, lying at an angle of 45 deg. to the vertical.

The oil-pressure system for operating the steam inlet and exhaust valves eliminates all layshafts, eccentrics, rods, and such like mechanism. The arrangement is shown diagrammatically in Fig. 3, and is worked as follows: A simple plunger type of pump, driven from the main shaft, supplies oil at a pressure of from 350 to 450 lb. per sq. in. to the valves to be operated. The oil passes from the pump through a distributor worked by spiral gearing from the main shaft. Separate distributors are provided for the steam inlet and exhaust valves. They are shown at A and B. Each distributor is a simple cylinder in form, arranged with a series of ports on the barrel, in which a piston or plug with corresponding ports revolves continuously under action of the spiral gearing. The ports are so arranged in the cylinder and piston that once per revolution they register and give an impulse to the column of oil between them and the valves, thus opening the latter. An operator, directly connected to each valve, is interposed between this column of oil and the valve, to receive and transmit the impulse. It is under a constant pressure of oil direct from the pump on its upper side, and is subject to an intermittent impulse-pressure load on its under side. As soon as the impulse load is released, the constant pressure closes the valve. The operator on its under side is of greater area than on its upper side, and this difference gives the upward load required to open the valve when the ports in the distributor register. The exhaust-valve distributor is extended to include a series of ports which are used for operating the steam-inlet valves to give a late cut-off when starting up the engine. This (exhaust and starting) distributor is fitted with a shuttle valve which is set by oil pressure for ahead or astern running. The steam-inlet distributor, on the other hand, is provided with a slipping arrangement on the plug coupling for this purpose.

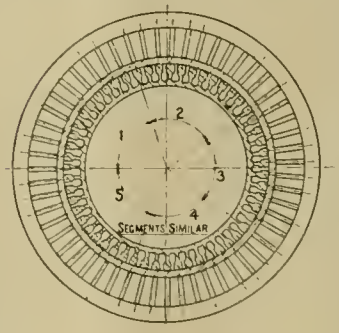
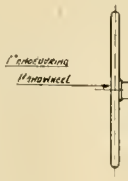


Fig. 2.—Combustion Cylinder Ribbing.

Starting and Manœuvring.

As the engine is started up and manœuvred by steam, the control of these operations is effected through the distributors. A control box, operated by the main manœuvring hand-wheel at the starting position, is connected to the oil-pressure system. In construction this control box is like the distributors, and consists of a cylinder, inside which a plug is rotated by the hand-wheel referred to. It is shown at F, Fig. 3. On moving the manœuvring hand-wheel to "Ahead" on the dial the shuttle valve in the exhaust and starting distributor is set by the oil pressure for ahead running. Further movement of the hand-wheel to the "Starting" position on the dial connects the starting end of the distributor to the steam-valve operator on the cylinder to give a late cut-off and starts the engine. Further movement of the hand-wheel to the "Running" position on the dial cuts out the starting steam-distributor, brings in the running steam-distributor with its early cut-off, and puts the engine on fuel oil. Should it be desired to run on steam only, the hand-wheel is simply brought to rest at the "Steam" position on the dial. A simple interlocking device is fitted to prevent the engine being run on oil except when the hand-wheel is in the "Running" position, and steam is available for piston cooling. "Astern" running is obtained and controlled in exactly the same way as ahead running, by reversing the direction of movement of the manœuvring hand-wheel. During the process of starting up and manœuvring, the oil-pressure supply is obtained from an independently driven stand-by pump.

Reversal of the fuel-pump action is obtained by fitting a separate astern cam and moving the cam roller from one cam to the other.



The auxiliaries required, in addition to the fuel-injection pump and valve-gear operating pump already referred to, consist of a forced lubrication pump and a scavenging air blower for the combustion side; and for the steam side a small condenser with air, circulating, and feed pumps, and a regenerator with feed-heater, filter circulating-pump, and filters. The filter circulating-pump is a simple displacement pump arranged to draw from the regenerator and discharge back into it again, a filter being arranged in the circuit. The scavenging air from the blower is led to the bedplate, thence up the columns to the ports in the combustion-cylinder liner. The bedplate and columns are thus used as a scavenging air reservoir.

On the steam side a shut-off stop and throttle valve is inserted in the main steam-pipe from the regenerator. The stop valve is used simply to give control over the steam pressure carried in the regenerator, whilst the throttle valve is connected to the governor. The exhaust steam from the low-pressure cylinder is led to the condenser through a grease extractor. A governor of the common ball-type is fitted to the engine. It acts through a servo-motor, and controls the setting of the spill valve on the fuel-injection pump. It is adjusted by means of a small hand-wheel control passing through the centre of the main manœuvring hand-wheel, and may be set by this means to control the speed of the engine at any revolutions from about 50 to 130 per minute. Independent hand-control of the spill valve is also arranged. The servo-motor receives its power from the forced lubrication system. On the steam side the governor acts as a spindle cut out at maximum revolution, and operates the throttle valve.

In starting up from cold, the burner under the regenerator is lighted, and steam is raised as in an ordinary boiler. As soon as the temperature in the regenerator begins to rise, it is found that a natural thermal circulation of the water between it and the cylinder takes place, so that by the time steam is raised the engine is thoroughly warmed up. The actual starting of the engine is then accomplished by means of the manœuvring hand-wheel in the manner already explained when describing the valve-operating gear.

Trial Results.

Reliability being more important than economy of fuel consumption in a marine engine, the opportunity was taken towards the end of August, 1921, to commence an endurance trial of the experimental engine.

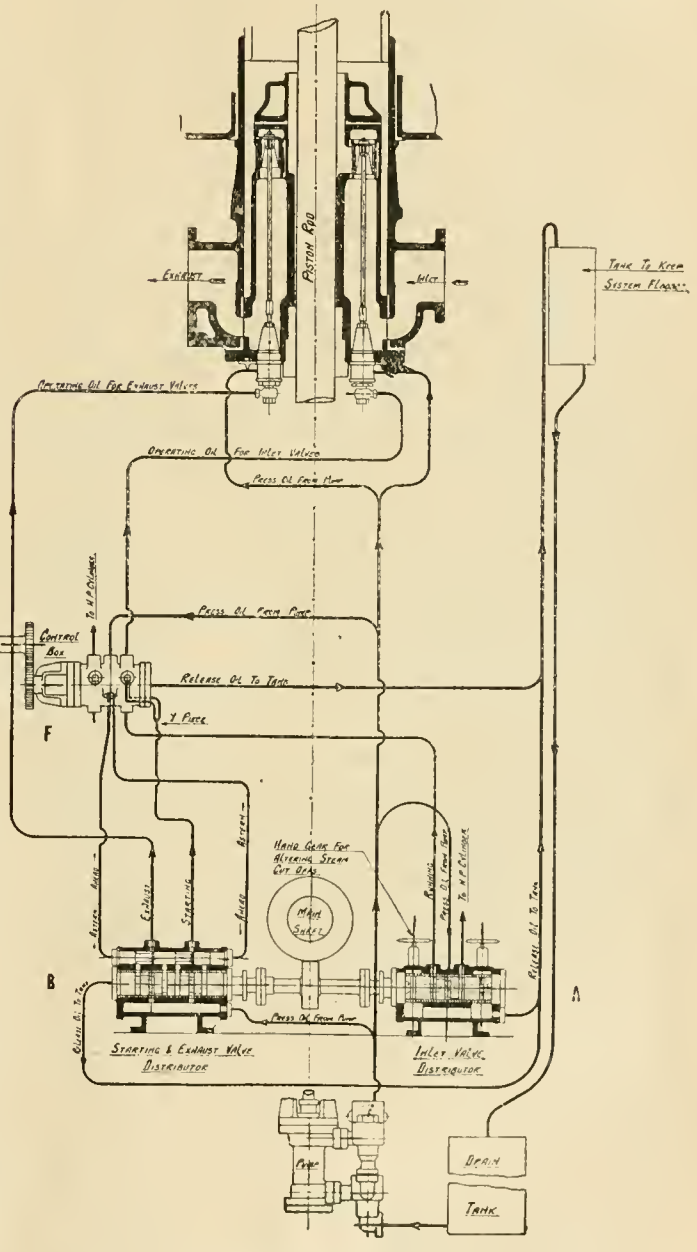


Fig. 3.—Diagram showing Oil Operation of Steam Valves and Engine Control.

The engine was run continuously for 14 days and nights, except for two short stops, both of which were occasioned by the breaking of the fuel-valve spring. In a multi-cylinder engine a stop would not have been necessary to change the spring, but in this single-cylinder engine it was deemed advisable to do so. The trial was undertaken at about mean-service power, primarily to demonstrate the engine's reliability and without special regard to fuel consumption, whilst the conditions were made to approximate as closely as possible to

those usually met with on board ship. Results are given in the following table. The figures for each day are the means of hourly readings, and a study of them will emphasise the great steadiness of the engine performance throughout the whole period of the trial.

Average Readings for Fourteen Days. Endurance Trial. August 24 to September 7, 1921.

Temperatures—	
Test room	62° Fahr.
Feed measuring tank	73° ,,
Feed leaving feed heater	229° ,,
Condenser circulating water inlet	57° ,,
Do. do. outlet	83° ,,
Oil in valve-gear oil tank	110° ,,
Oil in lubricating oil tank	97° ,,
Pressures—	
Valve-gear oil system	384 lb. per sq. in.
Lubricating oil to bearings	8·9 ,,
Oil-fuel injection pressure	5,300 ,,
Lubricating oil used—	
For cylinders, main and auxiliary	1·5 gall. per day.
For hand lubrication	1·1 ,,
Lost by leakage	2·3 ,,
Water lost per 1,000 b.h.p. per 24 hours	1·41 tons.

On the conclusion of this trial the engine was opened out for examination, particularly as to the condition of its combustion side, and it was found to be in a satisfactory condition.

The following extract from the report of Lloyd's representatives, who were present every day during the trial, will be of interest :—

" Upon the completion of the endurance test, the engine was submitted for examination. The cylinders, piston, piston rod, and the feed-water filter were opened out for examination, and found in good condition. It was not considered necessary to examine the crankshaft, crankpin, or the piston rod crosshead. The boiler was examined internally, and found good and absolutely free from oil.

" From the start to the finish of the trial during the 14 days' continuous working the engine ran excellently ; no trouble was caused by any part other than the breaking of the fuel-valve spring on two occasions (a contingency common to all internal-combustion engines), and the partial loss of vacuum on one occasion.

" From the records* given above, it will be observed that there is great regularity as regards the revolutions and the brake horse-power, and, in conclusion, we would state definitely that not only did the engine run well throughout the trial but was in thoroughly good condition at the finish."

Typical indicator cards taken on trial are shown in Fig. 4. The oil fuel used on all trials up to September, 1921, was shale, having a calorific value of about 19,300 B.Th.U's. gross (18,240 net) and a specific gravity at 60° Fahr., varying from 0·85 to 0·87.

Tests undertaken with heavy oils also gave satisfactory results.

Large Powers.

Like all other oil engines, large powers in the Still engine are obtained by multiplying the number of cylinders. The engine lends itself very readily to construction in groups of three cylinders, and two or three groups may be arranged on one line of shafting. In each group one cylinder on its steam side is arranged to work as a high-pressure cylinder, and the two others as low-pressure cylinders. Groupings of four and five cylinders may also be arranged quite easily ; in these cases one high-pressure cylinder will exhaust into three of four low-pressure cylinders respectively, the correct volumes being obtained by varying the cut-offs. Taking, for example, a group of three cylinders, as compared with the single-cylinder experimental unit, the steam available for compounding will be that generated from the products of combustion of the oil sides of these three cylinders. The high-pressure cylinder of the group will pass all this steam through it, and each of the two low-pressure cylinders will deal with 50 per cent. more steam than the quantity generated by its own combustion side. This point is of considerable importance, for, as has been mentioned previously, dependence is placed on the steam to keep the piston cool. In this and in other respects the single-cylinder unit that has been described is at a distinct disadvantage, and improved results may, therefore, be looked for in multi-cylinder engines.

* Records accompanying the report.

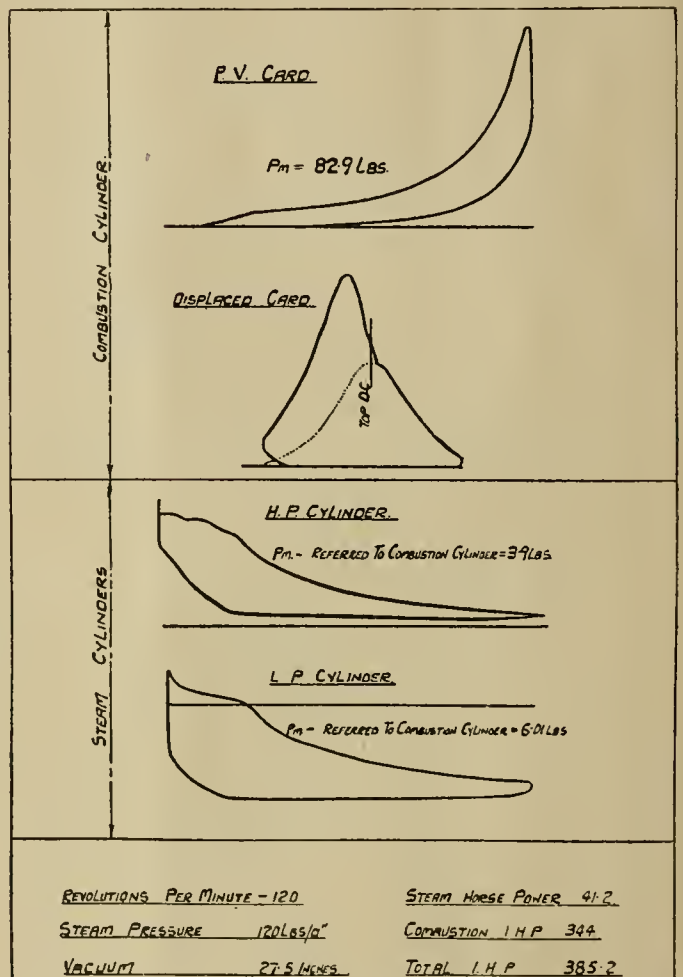


Fig. 4.—Typical Indicator Cards taken at Full Normal Load—14 Days' Trial.

It might not be out of place to mention that Scott's Shipbuilding Company received an order a few weeks ago from Alfred Holt & Co., Liverpool, for a vessel, 400 ft. in length, to be fitted with an installation of Scott-Still engines to develop 2,500 b.h.p. with twin screws in normal sea service. This may be taken as an indication of the confidence which is being placed, in shipowning circles, in the future of this new prime mover.

The "Mauretania."—The *Mauretania* leaves the Tyne shortly to resume her place in the Cunard service from Southampton to New York as an oil-burning vessel. For some months past she has been in the hands of Swan, Hunter and Wigham Richardson Limited, undergoing reconditioning. Extensive renewals have been made in her accommodation. The *Mauretania* will resume her place this month in the express Channel service with *Aquitania*, and later on will be joined by the *Berengaria*, now undergoing conversion into oil-fuel burning and reconditioning by Sir W. G. Armstrong, Whitworth & Co., Walker-on-Tyne.

THE ECONOMICAL ARRANGEMENT OF MACHINERY SPACES.

Comparison between Scotch Boilers with Coal and Water-Tube Boilers with Oil Fuel—Observations on Accommodation.

The science of marine engineering has made great progress during the last few years, and since the beginning of the century many different types of propelling machinery have been evolved and tried under service conditions. The advance of engineering was undoubtedly accelerated during the war, and we are now in a position to consider minor improvements which would tend towards greater overall efficiency. This contribution is not intended to be a discussion on the merits and demerits of different forms of main machinery, but there are details of machinery space design and arrangement which do not seem to receive the attention they deserve. Few radical changes can be made in the main machinery at present, and a vessel can only be improved by the consideration of details.

When a new design is contemplated, one of the principal problems which confront both shipowner and shipbuilder is the type of boiler which would be most suitable for the intended vessel and its service. The majority at once decide on the familiar Scotch type, simply because it has the reputation of being more reliable than the more recent water-tube boiler. This matter of reliability is open to question. Ships of all classes, from liners to ordinary cargo ships, have shown by service results that the water-tube boiler is reliable and economical. It is admitted that more careful and expert attention is required, but the modern engineer seems to be quite capable of overcoming any operation difficulties.

The important effect of weight on the design of a ship is too well known to need comment, and in this respect the water-

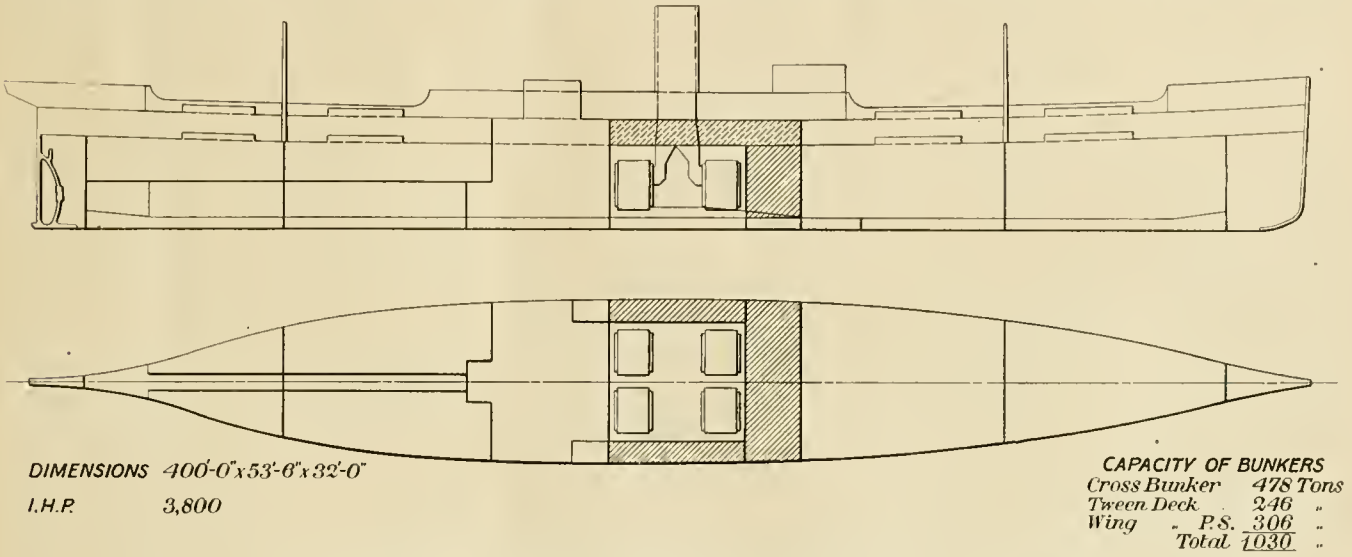


Fig. 1.—Vessel equipped with Four Single-Ended Cylindrical Boilers working on Coal Fuel.

Total boiler room weight (includes mountings, uptakes, funnel, &c.), 498 tons.

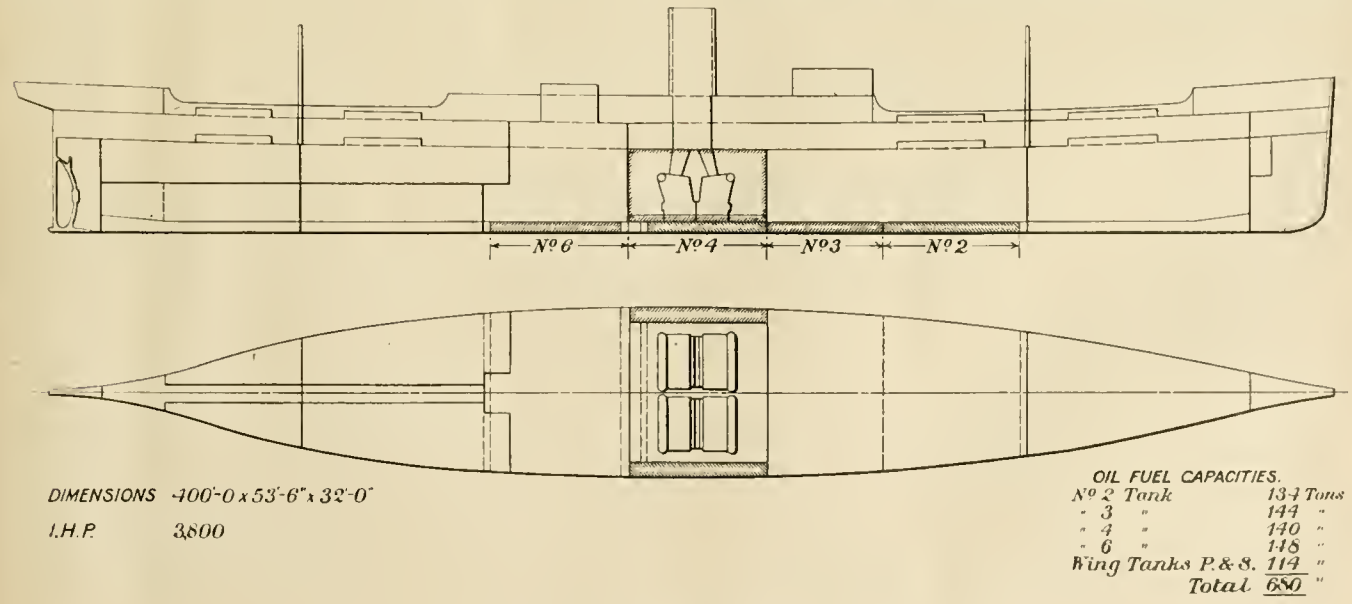


Fig. 2.—The same Vessel with Water-Tube Boilers and Oil Fuel.

Total boiler room weight (includes mountings, uptakes, funnel, &c.), 410 tons.

tube boiler has a great advantage. It has been argued that the large amount of water carried by the cylindrical boiler leads to a more uniform distribution of heat and a safer installation, but from the shipowner's point of view, this weight of water is a reduction of the profit-earning deadweight of the vessel. Another point that is raised in defence of the old system is that the larger amount of water carried is more able to take up any sea water which might leak into the boiler feed, and also that this water acts as a storage for thermal energy, levelling up temperature differences. Experience has shown repeatedly that no trouble arises in the water-tube boiler if the leakage is not extraordinary, and there is little to choose between the two types in this respect. The great advantage lies in the fact that this unnecessary weight of water is dispensed with, and the saving can be used to increase the deadweight, or, alternatively, to decrease the size of the ship.

There seems to be no logical reason why water-tube boilers should not be more widely adopted, and no doubt in time the conservative policy which prevents their adoption will disappear.

The question of fuel is one that should be considered in conjunction with that of the boilers. A great many engineers are oil fuel enthusiasts, and demand oil fuel without considering the financial side of the question. It is evident that the best fuel is that which will give the most economical results after all possible factors have been taken into account, and although higher machinery efficiency is obtained with oil, it does not necessarily follow that the profits will also increase. The two main factors are those of cost and certainty of supply, and the shipowner must consider the problem from these points of view before coming to a decision.

Influence on Deadweight Capacity.

There are great advantages attendant upon the use of oil, not the least being the increase of deadweight capacity. This is illustrated by Figs. 1 and 2. Fig. 1 shows a vessel equipped with four single-ended cylindrical boilers working on coal fuel, the capacity of the bunkers being sufficient for just over 16½ days' steaming on full power.

In Fig. 2 the same vessel is shown equipped with water-tube boilers and oil fuel, and the increase of capacity is well illustrated.

The increase of cubic capacity amounts to 25,150 cubic feet. This takes account of the sheathing which must be fitted on the tank top in way of the fuel tanks. The gain in weight due to lighter boilers and less fuel is 438 tons, of which 350 tons is due to the use of oil fuel.

It is not a difficult operation to convert a vessel from oil to coal, and if there is a possibility of a vessel ever having to burn oil, it would probably be an advantage to construct the ship for this purpose. During the war, oil was successfully carried in double-bottom tanks of ordinary watertight construction. This has been generally accepted by the registration societies for double-bottom tanks, the only stipulation being that the centre line division must be oiltight and that a more severe test head shall be applied. In the case of peak tanks, settling tanks and deep tanks, which are used for oil fuel, the construction must be in accordance with general oiltight work and of a substantial character, special stiffening being required to withstand the forces caused by the surging of oil when the ship is in a seaway. There seems to be a good opportunity for the application of welding in connection with oiltight work; absolute oiltightness is difficult to obtain with riveting, and there is little doubt that wider-spaced riveting in conjunction with welding would give better results, although the cost would be slightly higher.

The heavy crude oils which are used at present need heating before they can be pumped easily, and a good heating system in the tanks gives an oil with low viscosity which can be easily pumped to the boilers. For effective transmission of heat to the oil the pipes should be as thin as practical considerations will allow, and about 1 sq. ft. of heating surface should be allowed for each ton of oil, although it is advisable to increase this figure for voyages in North Atlantic and similar waters.

The usual practice with regard to the piping is to fit a coil at each suction, the coil usually being placed round the pipe just above the strum box. A more economical arrangement is to dispense with the strum box, and shape the heating pipes into a beehive form at the base of the suction pipe. Distance pieces should be placed between each complete turn, and also between the shell plating and the lowest coil, so that the complete coil acts as a strainer. The oil, flowing between the hot pipes, becomes less viscous, and the work of the oil pumps is rendered easier.

The importance of efficient steam pipe connections is obvious, and the piping should be fitted with the maximum lengths obtainable. The pipes themselves should be of galvanised iron of about 1½ in. diameter, as any other material would cause corrosion owing to foreign matter in the oil.

Arrangement of Coal Bunkers.

With regard to coal, it seems that in some vessels the arrangement of bunkers is far from ideal, being inconvenient for coaling and trimming. Easy firing arrangements in the stokehold may not directly affect results, but the personal element undoubtedly plays a part in the final efficiency. Better firing can be obtained if there is less trouble in transporting coal from the bunkers to the furnaces. For ease of coaling and subsequent working wing bunkers have much to recommend them, since the distance from bunker door to furnace is reduced to a minimum. In many ships the capacity of wing bunkers is insufficient, and increased stowage is obtained by means of 'tween deck and cross bunkers, both types reducing the cargo capacity. A common arrangement is that shown in Fig. 1, and it will be seen that it is difficult to work the coal from the cross bunker, since it has to pass between the forward boilers.

From the stability point of view a 'tween deck bunker is much better than a hold bunker. In the burnt-out load condition there is little reduction in metacentric height in the former case, and by giving the vessel a moderate G.M. it becomes a very "easy" ship in all conditions. Another advantage of 'tween deck bunkers is the reduction in the number of working doors in the bunker bulkheads, and if it is possible to confine the bunkers within the limits of the boiler space it is only necessary to have one door on each wing for each flat.

The arrangement and types of auxiliary machinery require much consideration, and the supervision of auxiliaries is perhaps more important than that of the main engines. The auxiliary steam consumption in some vessels is about 25 per cent. of that required for the main engines, and, consequently, the waste of energy due to radiation, leakage and bad design should be eliminated as far as possible.

The advantages of electric auxiliaries in this respect are well worth consideration, since the only important loss lies in the generators, which are under the direct control of the engine room staff. The heavy losses in steam pipes are replaced by the exceedingly small transmission losses in the cables, and the unsightly network of small steam pipes is dispensed with. The initial cost of electric auxiliaries is greater than that of steam-driven types, but the installation is cleaner and more easy to control. At present electric machinery seems to be regarded as an unnecessary complication in a ship, but, nevertheless, there are real advantages to be gained by its adoption. The marine engineer in charge must have sufficient knowledge to overhaul and repair the auxiliaries, but there is no need to carry an extra engineer for electrical work. The great objection at present seems to be the old question of reliability, but considering that many motor ships with electric auxiliaries have run for several years without any serious mishaps there should not be much doubt on this score.

Apart from the question of propelling machinery and machinery spaces, the accommodation for engineers and the engine room staff is a matter which should receive more attention when the ship is being designed. A good arrangement, with efficient lighting and ventilation, is well worth the extra time spent when the vessel is in the design stage, and under normal trade conditions there is little doubt that the ships with a reputation for comfortable quarters get the better class of men. A contented engine room staff will have a marked effect on the efficiency of the ship; the influence of the personal factor on efficiency cannot be put into definite figures, but it is a point that the shipowners cannot afford to neglect, and a little extra expense on this account would undoubtedly prove an economy in the end.

The first point that arises is the position in which these quarters should be placed in the ship. Since the introduction of steam ships it has been customary to put the engineers' cabins as near the engine and boiler spaces as possible, and the correct position was considered to be the 'tween deck immediately above the machinery spaces, so that the engineers were almost roasted whether on or off duty. In recent years it has been generally recognised that, in view of the comparatively unhealthy conditions under which engineers work, the cabins should be as high up in the ship as possible. In the average type of cargo vessel this has been quite a common feature for years, the chief reason being that it is more economical to house the engineers abreast the engine and boiler casings on the weather deck than to lose cargo space by putting the accommodation below the deck.

In the larger types of passenger vessels, however, there is usually some difficulty in arranging the cabins and mess spaces so that they will not be too near the passenger spaces, and it is for this reason that the engineers are often found in their old position, which is practically on top of the boilers. In this respect the design of some of the newer American vessels is open to criticism, and it would possibly have been better to accommodate the whole of the officers in a house on the boat deck, removed from the passengers.

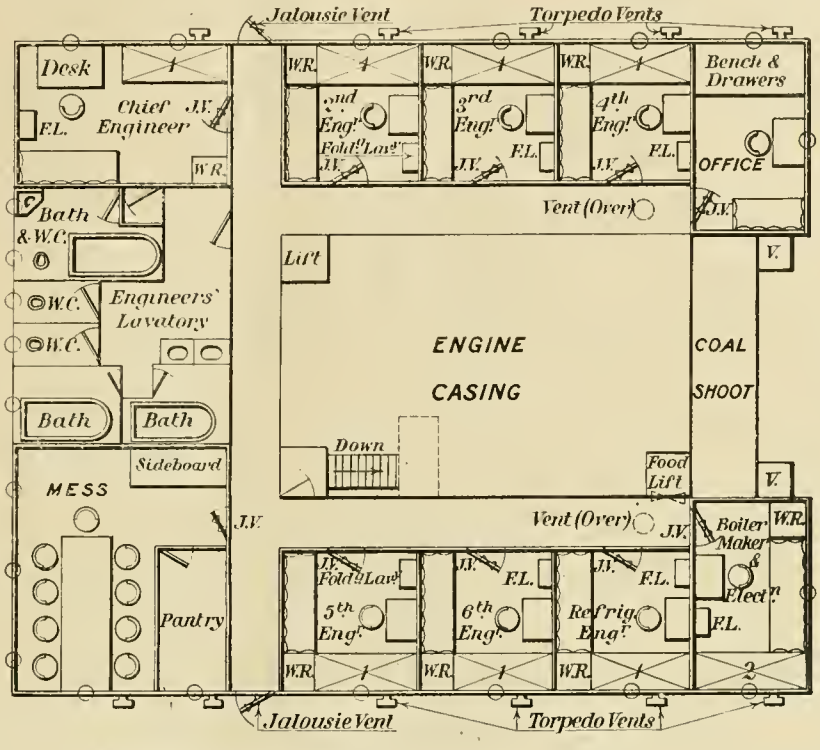


Fig. 3.—Suggested Arrangement of Engineers' Accommodation on Boat Deck of large Vessel.

A typical sketch of such an arrangement is shown in Fig. 3, which shows the engineers' house as designed for a large trans-atlantic vessel. Accommodation of this type can only be fitted when the boat deck has a breadth of 64 ft. or more, and in the case of smaller vessels the alternative method of a double fore and aft passage beside the casings must be adopted, similar to that commonly used in cargo vessels.

With regard to the firemen and similar members of the crew, the matter of accommodation must of necessity depend on the intended service of the ship, but in general it is best to house all the lower ranks of the engineers' staff on, or just under, the after end of the weather deck. In that case the firemen are absolutely isolated from the passengers, and can reach the engine room by means of a firemen's stair to the shaft tunnels. This arrangement has been tried in several recent vessels, and is admitted to be one of the best possible solutions to what has always been a vexed question.

SPEED-REDUCTION GEARING.—II.

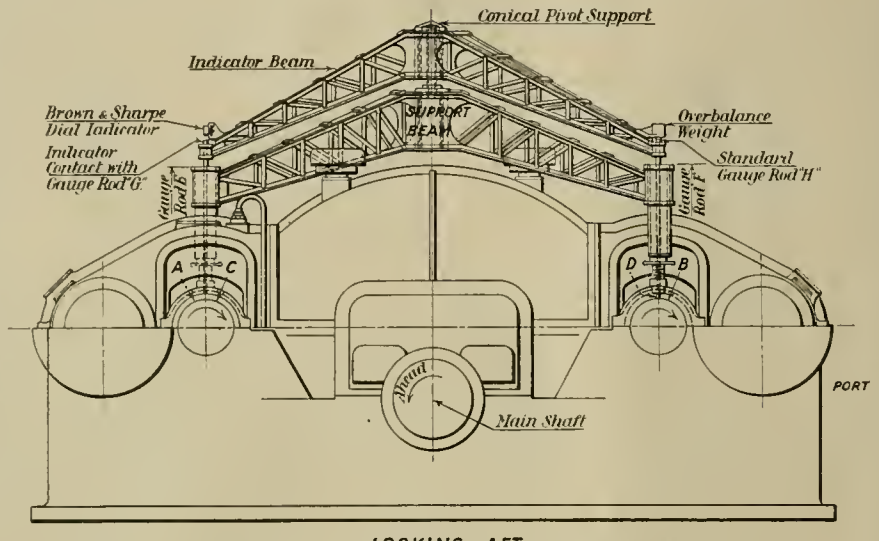
The Practice of the Metropolitan-Vickers Electrical Company Limited—Ensuring Accuracy—An Alignment Meter for Gearing.

In last month's issue we gave particulars of the methods adopted by the Power Plant Company Limited, West Drayton, for the cutting and erection of speed-reduction gearing for use on board ship, together with details of the equipment employed. Another firm who have considerable experience in this class of work is the Metropolitan-Vickers Electrical Company Limited, whose works are situated at Trafford Park, Manchester. This firm also build a very sturdy form of marine turbine of the impulse type, as well as the necessary condensing plant, so that they are in the position to supply the complete sets of propelling machinery. A complete set of compound marine turbines of 4,200 s.h.p. in course of erection is shown on page 117. These have now been installed in ss. *Amsterdam*, a vessel building by Lithgows Limited, Port Glasgow, for the Royal Netherlands Steamship Company.

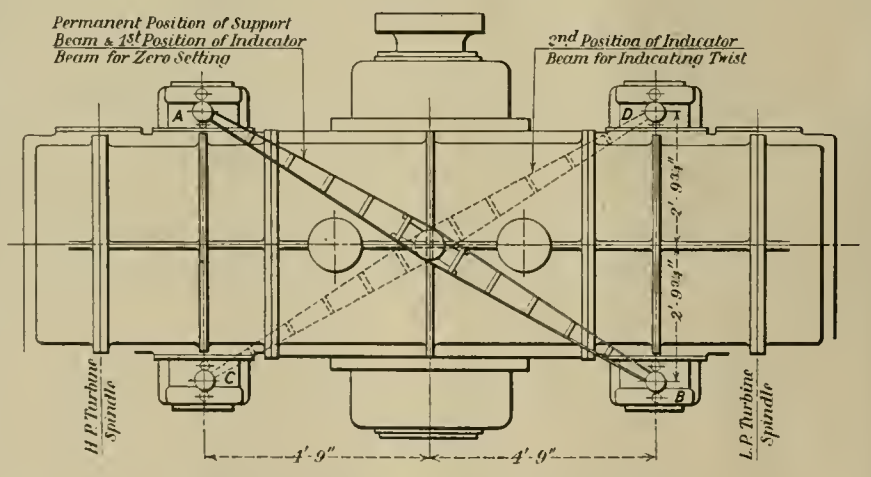
The Metropolitan-Vickers Company have adopted the hobbing system for the cutting of the teeth on the gear wheels and pinions, particular care being taken to ensure that a very high degree of accuracy is obtained. In the first place, the machines installed for hobbing the gears were thoroughly tested before being put into service, to make absolutely certain that there were no appreciable errors which might adversely affect the accuracy of the finished gears. In the hobbing machine a cutter in the form of a worm is employed, which is driven at a speed synchronous with the speed of rotation of the wheel, the cutter being fed in a vertical direction, thus gradually covering the entire peripheral surface of the wheel. The teeth on one-half of the wheel can thus be cut in one operation, although it is usual to give a roughing cut followed by a finishing cut taken by a very accurately formed cutter. The slope of the cutting worm is reversed when the teeth on the second half of the double helical wheel are being machined. One of the hobbing machines by William Muir & Co., Manchester, installed at the works of the

Metropolitan-Vickers Company, is shown on page 116. The second half of a gear wheel is being cut and the operation is nearly completed. A number of pinions is seen in the foreground. A closer view of this machine, showing the cutter in operation, is shown above it. The form of the cutter can just be discerned through the spray of soapy water which is projected on to the cutter to keep it cool. A finished gear wheel is shown on the left.

In addition to taking every precaution to ensure the accuracy of the hobbing machine, measuring machines have been designed and patented for the purpose of testing the accuracy of the hobs used in cutting the teeth and also for testing the finished pinions. These measuring machines are provided with scales reading to $\frac{1}{10000}$th of an inch, so that it is possible to check the dimensions of the hobs and the finished pinions to these limits. It is, however, not enough to have accurate cutting machinery if the material of the wheels and pinions is liable to distortion during and after machining. Hence very great care is paid to the selection of the material employed. It is claimed that all these precautions ensure that gearing produced in the Metropolitan-Vickers works possesses that high degree of accuracy which is essential in the production of reliable marine speed-reduction gearing. A general view of the heavy machinery aisle of the works at Trafford Park is shown on page 118, the gear-cutting machines being seen in the left foreground of the picture. Turbines in the course of erection can be seen in different parts of the shop. Gears are shown on page 115.



LOOKING AFT.



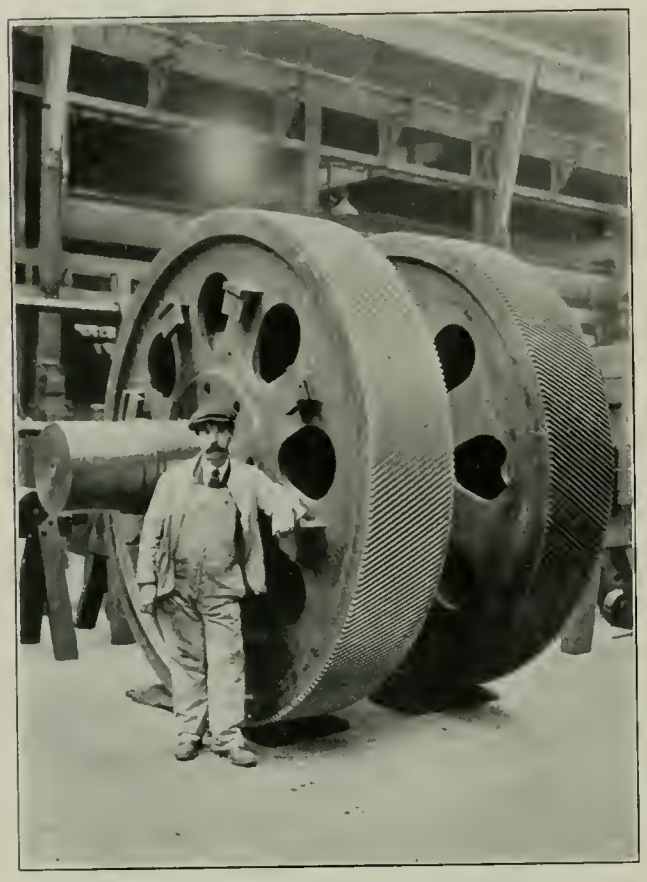
Alignment Meter for Turbine Gear Shafts.

A source of trouble with speed-reduction gearing, particularly with gearing of the double-reduction type, is the error in alignment between the various shafts which may develop during erection. It is essential that these should be in perfect alignment, both during erection in the shops and when the gears have been installed on board ship and are in actual service. In order to test the alignment of the gears, the Metropolitan-Vickers Company have developed a special form of alignment meter, which enables the alignment to be readily checked at any time, even with the gears in operation. This alignment meter, as erected on a set of double-reduction gears, is shown on page 117, the arrangement being shown diagrammatically above. The apparatus consists essentially of two duralumin beams, the lower one supporting the upper at its middle part, arranged diagonally across the gear casing, the ends of each beam being provided with pivots which rest in contact with the pinion shafts at the points A, B, C and D, the diameters of the shafts being accurately measured by means of a micrometer gauge at these points. For accuracy of alignment, the point C must be in the plane containing the points A, B and D. The lower beam, called the support beam, rests upon adjustable hand wheels which operate upon hollow supports fixed in the bearing caps at A and B, so that by adjusting the hand wheels the top of the support beam end over B can be brought level with the top of the gauge rod F, this rod passing through the bearing cap and resting upon the shaft. In like manner, the gauge rod E fixes the position of the other end A of the support beam, so that the position of the conical pivot at the top middle point of the support beam is fixed relatively to the points A and B on the shafts. The gauge rods E and F are now replaced by two other gauge rods G and H, and the indicator beam is swung over on the pivot until it lies vertically over the support beam, so that the faced underside of the overbalance weight mounted at one end of the indicator beam rests upon the top of the gauge rod H. At the other end of the indicator beam is a Brown & Sharp dial indicator, graduated in thousandths of an inch; this is adjusted until the point of the indicator rests in contact with the top of the gauge rod G. In this way a reading is obtained, the dial being turned to make this reading zero.

The beam is now swung round and the gauge rods G and H are placed in the bearing caps at C and D respectively. The beam is moved so that the overbalance weight again rests upon rod H in its second position at D. The indicator contact point now rests on the top of the gauge rod G, and if the indicator shows a zero reading, the two pinion shafts AC and BD are in the same plane. If a reading other than zero is obtained, the reading will serve as a guide for packing up the gear case. All the adjustments and settings are made when there is no load on the gearing, and when it is at rest. For testing the alignment when the gearing is in motion under load, the gauge rods E and F are replaced through the support beam ends at A and B respectively, and the hand wheels adjusted as before, bringing the conical pivot back to the same position relatively to A and B. The zero setting is regained while the indicator beam is still in its working position over C and D. The dial indicator can therefore be read at any time.

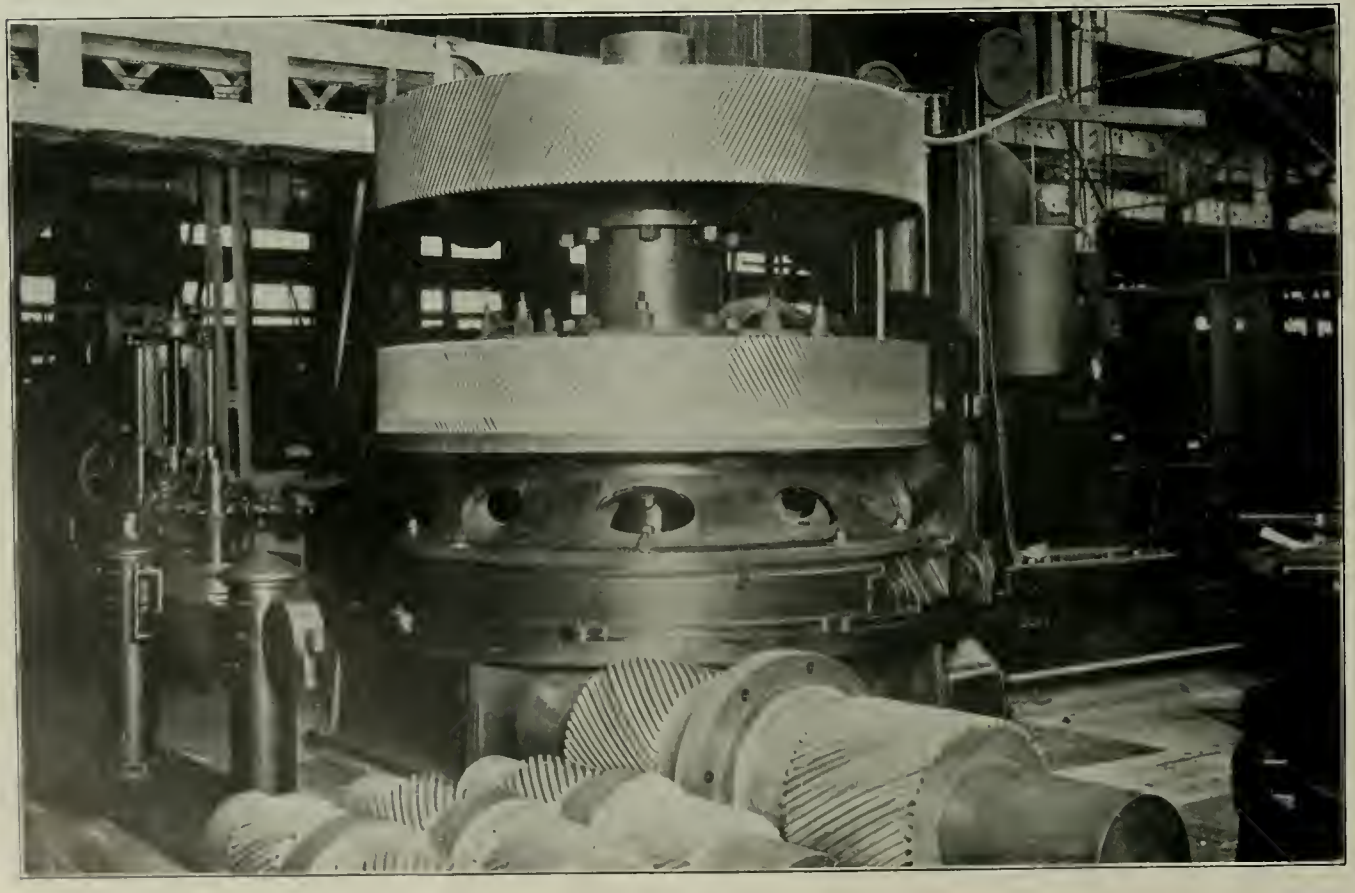
Marine Turbine Gears constructed by Metropolitan-Vickers Ltd., Trafford Park. (*See page* 114.)

GEAR CUTTING AND TURBINE CONSTRUCTION AT



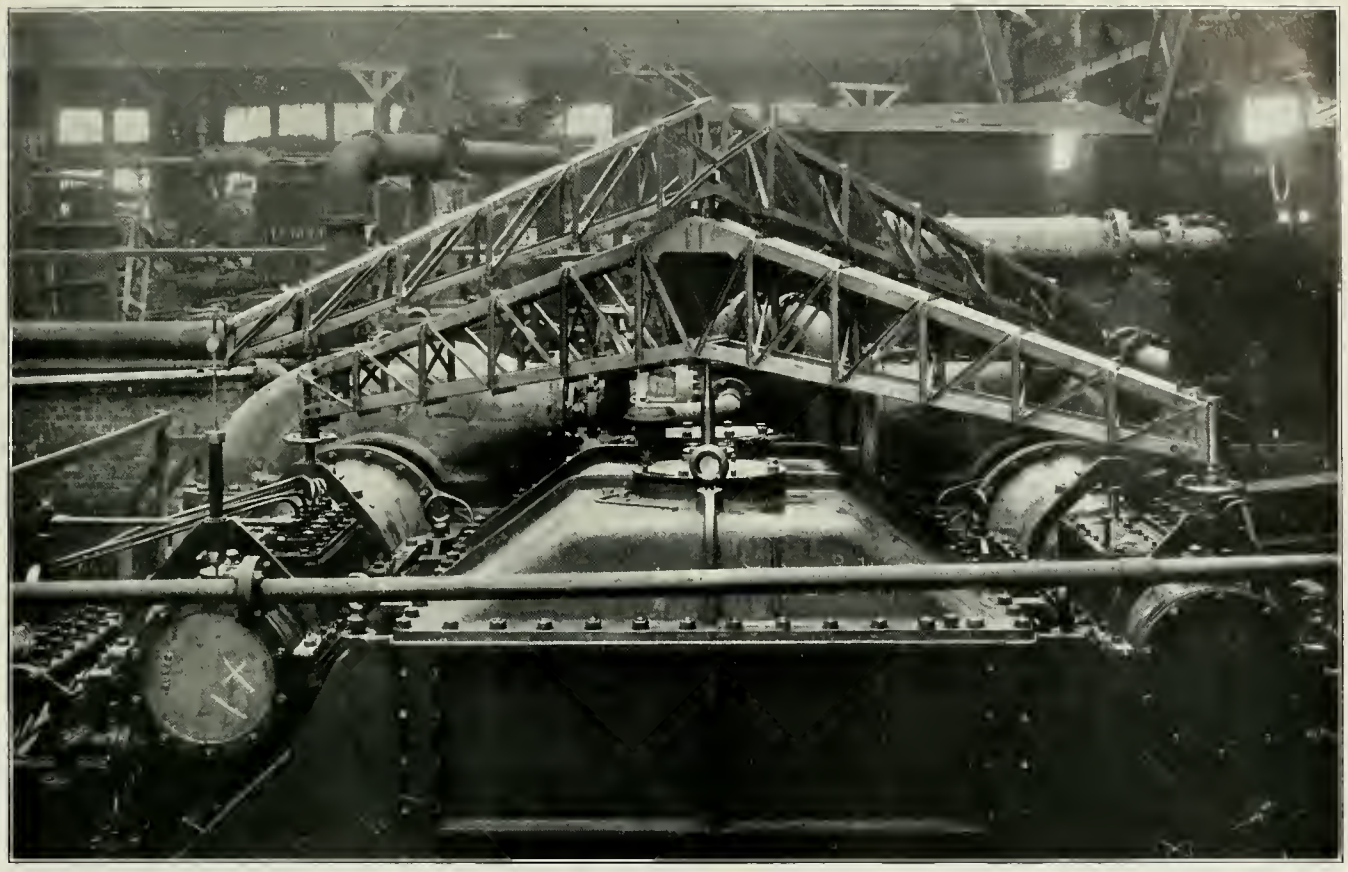
Pair of Finished Gear Wheels.

Cutting large Gear Wheels for Marine Propulsion.

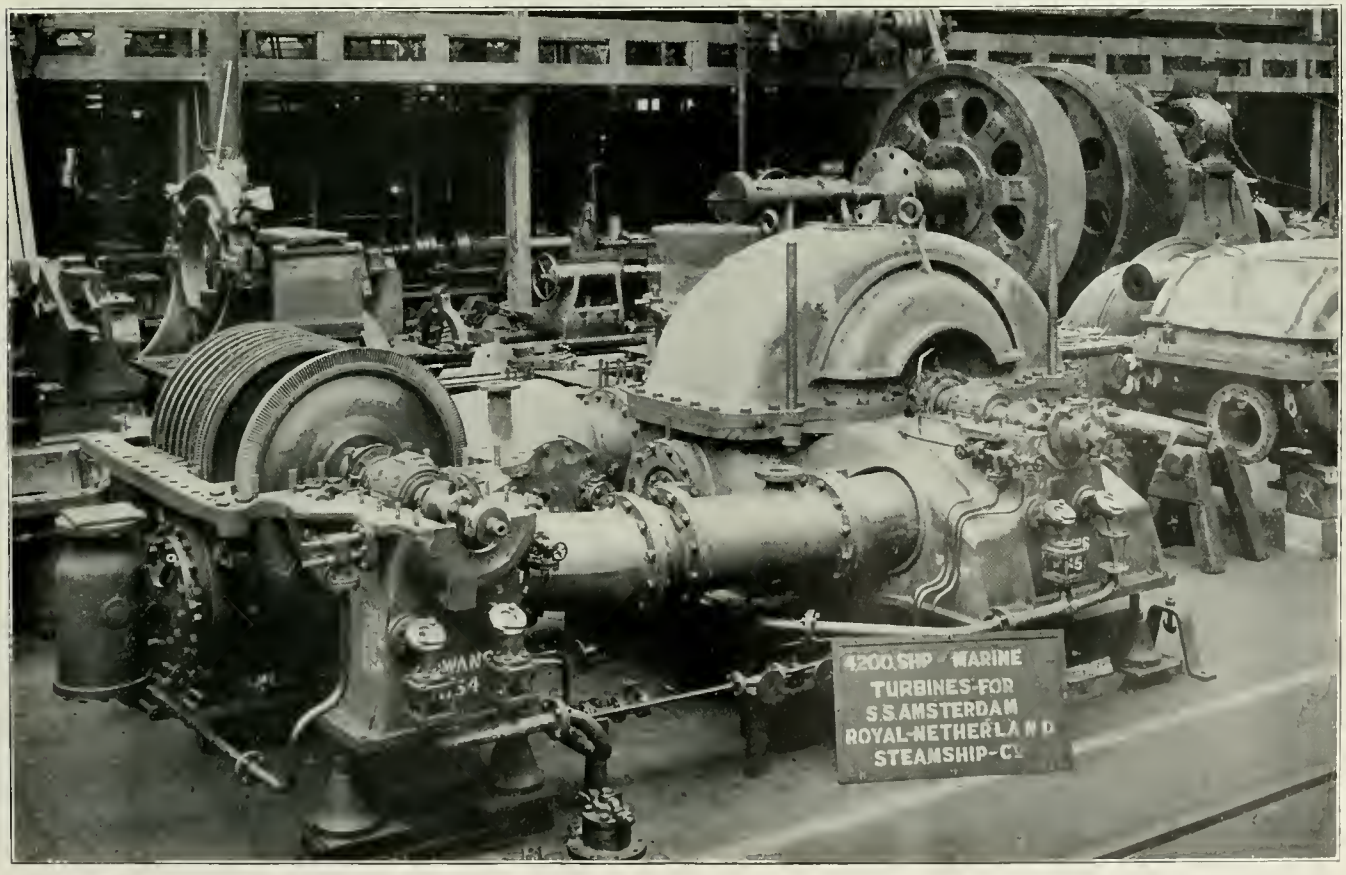


Cutting large Gear Wheels for Marine Engines on a Muir Hobbing Machine.

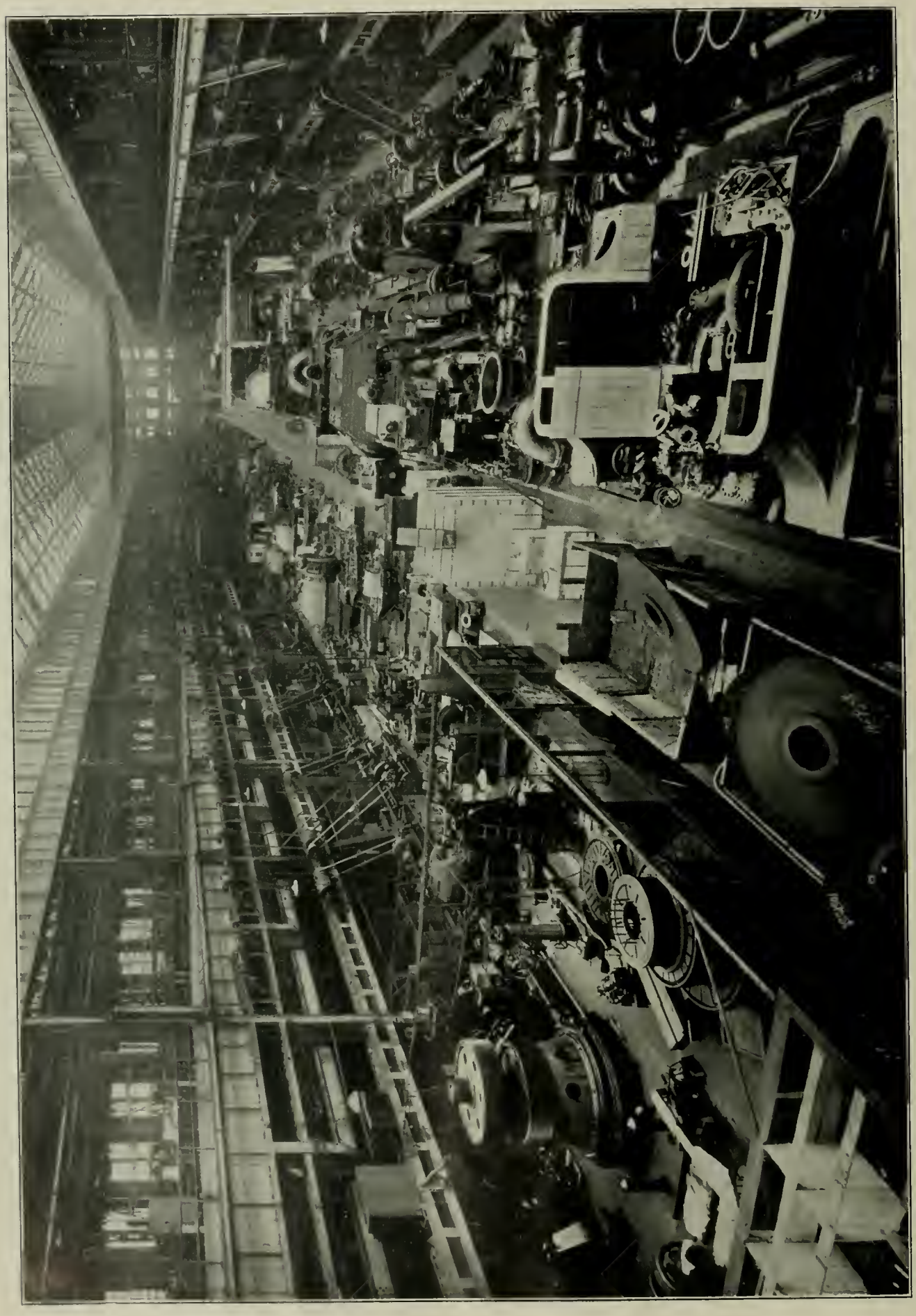
THE METROPOLITAN-VICKERS' WORKS. (*See page* 113.)



Alignment Meter in Use at Metropolitan-Vickers' Works.



Marine Turbines in course of Construction for the Royal Netherland Steamship Co.



General View of Mechanical Aisle, Metropolitan-Vickers Electrical Co. Ltd., showing Gear-Cutting Machines on the left foreground. (*See page* 113.)

PROPELLERS FOR OIL-ENGINED VESSELS.—III.

Effect of Fullness, Angle of Bossing and Transverse Position of Screw on Wake.—Conclusion.

The remarkably high wake values found by analysis of the *Suecia's* trials have caused the writer to examine afresh the published experimental data relating to wake and thrust deduction.

It was pointed out, in the preceding article, that the intensity of wake measured seemed to depend to some, and probably to a large, extent on the diameter of the screws. When small screws are revolving at high revolutions for the propulsion of heavy and full ships normal wake values do not seem to hold.

Further, the writer considered that the very high wake value found by analysis might be justified when the angle of bossing was taken into consideration. Mr. Blache said in his paper, "With regard to twin-screw vessels it is important that the angle of the bossing should be good; if not, the increase in resistance will be considerable. *The bossing in our vessel is almost horizontal*, the top side being straight and the underside hollow, so that the stream lines along the after body are directed horizontally to the propellers."

The line of investigation which suggested itself was to find the effect on wake of (1) fullness of ship; of (2) angle of bossing; of (3) transverse position of screw; and (4) diameter of screw in relation to thrust delivered. Fortunately, sufficient experimental data is available to allow satisfactory conclusions to be drawn in relation to these points.

Effect of Fullness of Ship on Wake.

From the plot of the results of many screw experiments with ship models, the following approximate formulæ have been given for wake values.

Rear-Admiral Taylor gave the following in the 1910 Trans. Institution Naval Architects, page 83, the "w" being expressed as a fraction of the speed of the ship.

$$"w" = -\cdot 2 + \cdot 535 \text{ block coeff.}$$

Professor Hillhouse found that certain wake values published by Professor McDermott for various forms could be approximately formulated as follows:—

$$"w" = 30\,p - \cdot 75\,\frac{L}{B} - 5\cdot 5$$

where p = prismatic coefficient.
L = Length on W.L.
B = breadth on W.L.

(Trans. Institution Naval Architects, 1910, page 88.)

The above formulæ and other published results indicate the effect of fullness on the wake values.

Effect of Angle of Bossing on Wake.

The most complete data dealing with wake and thrust deduction has been given to the shipbuilding world by Mr. W. J. Luke in his three papers read to the Institution of Naval Architects in 1910, 1914, and 1917. The effect of angle of bossing was investigated on a model 200 in. by 30 in. by 9 in. and ·65 block coefficient with twin propellers 6 in. in diameter. Experiments indicated that with this particular form, and screws of the given diameter, the "w" = ·21 with no bossings.

Bossings were afterwards fitted on the model. Since it was desired to find the effect of the angle and not the shape of bossings, these appendages were made uniformly ¾ in. in thickness rounded at the outer edge and well tapered off abaft. The following results were obtained :—

Angle of bossings.	Wake.		Thrust deduction.		Hull efficiency.	
	Outward turning.	Inward turning.	Outward turning.	Inward turning.	Outward turning.	Inward turning.
0° (horizontal)	·32	·11	·165	·157	1·110	·940
22½°	·24	·17	·168	·160	1·025	·985
45°	·17	·23	·172	·164	·966	1·030
67½°	·11	·29	·182	·170	·905	1·065
90° (vertical)	·07	·34	·215	·190	·840	1·090

It was found, however, that, with the resistance of the naked model being taken as unity, the resistance of the horizontal and vertical angles of bossings were greatly in excess of those recorded for the intermediate angles, and that an angle of about 45 deg. from the horizontal offered the minimum resistance when the model was towed without the propellers.

In the following table the hull efficiency values obtained in the different directions of rotation are associated with the increase in resistance incurred by the different angles of bossings.

Angle of bossings.	Resistance over naked model resistance.	Hull efficiency.		Hull efficiency.	
		Outward turning.	Inward turning.	Resistance over naked model resistance.	
				Outward turning.	Inward turning.
0° (horizontal)	1·11	1·11	·940	1·0	·846
22½°	1·04	1·025	·985	·987	·947
45°	1·03	·966	1·030	·935	1·00
67½°	1·05	·905	1·065	·860	1·015
90° vertical	1·12	·840	1·090	·750	·975

From the foregoing it appears that a high wake would be looked for in the case of the *Suecia* because of her fullness and because her bossings were almost horizontal.

The above figures also indicate the danger of having outward turning screws associated with angles of bossing sloping very decidedly from the horizontal; further, that a low efficiency might be looked for when inward turning screws are associated with horizontal bossings.

Effect of Angle of Bossing on Full Ships' Wakes.

C model, on Fig. 8, shows the results obtained with outward turning screws on the model of ·65 block coefficient.

Fortunately, from the point of view of the present investigation, Mr. Luke carried his researches to models of finer and fuller forms, and the results of these he gave to the Institution of Naval Architects in 1917. Further, screws smaller and also greater in diameter were used behind the full model.

Rather unexpected results were obtained which have an important bearing on the *Suecia's* analysis. The investigation disclosed the fact that the *angle* of bossing had a much less effect on the performances of full models than on those finer in form, also that diameter of screw had an important bearing on the wake. The unexpected results with the 6-in. screws and with the different angles of bossing rather surprised Mr. Luke. In his paper he said, "As previous experiments had led to the expectation that the plot of the wake values on a base of fullness would have assumed an approximately

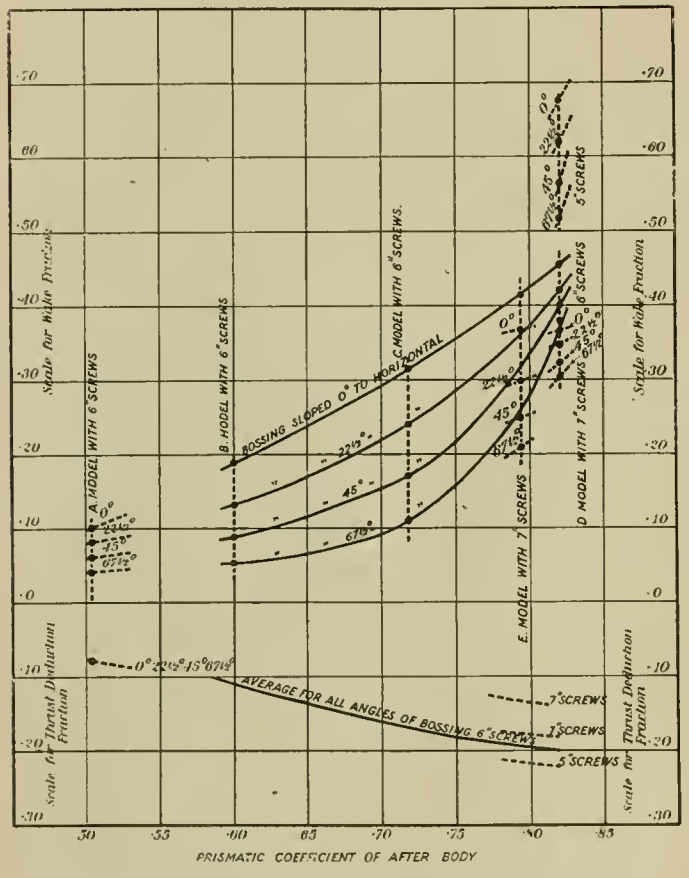

Scale for Wake Fraction
Scale for Thrust Deduction Fraction
A. MODEL WITH 6 SCREWS
B. MODEL WITH 6 SCREWS
BOSSING SLOPED 0° TO HORIZONTAL
C. MODEL WITH 6 SCREWS.
D. MODEL WITH 7 SCREWS
E. MODEL WITH 7 SCREWS
5 SCREWS
6 SCREWS
7 SCREWS
AVERAGE FOR ALL ANGLES OF BOSSING 6 SCREWS
PRISMATIC COEFFICIENT OF AFTER BODY

Fig. 8.—Curves showing the effect of Fullness and Angle of Bossing on Wake.

rectilinear form, the result was nothing short of disappointing. However, after considering a number of possible reasons for this result, it was at last concluded that although not much influence might have been exerted by the selected relations of length to transverse dimensions, yet for a model of the fullness adopted, the relation of width to depth was abnormal, and as a partial result of this the screws were on the small side. Sets of experiments with screws 5 in. and 7 in. in diameter were made and thoroughly confirmed this latter conclusion."—Trans. Institution of Naval Architects, 1917, page 108.

Referring again to Fig. 8, it will be seen that with horizontal bossings and with the 5-in. screws a "*w*" of ·67 was given. These screws are equivalent to a diameter of 10 ft. for a 400-ft. ship. The *Suecia* had a length of 362 ft. and screws 10 ft. in diameter.

Transverse Position of Screws.

In Mr. Luke's experiments a certain fixed transverse position of screws was chosen, so that screws differing in diameter

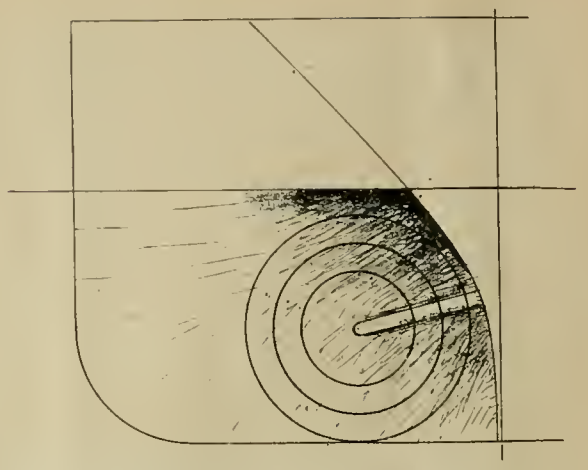


Fig. 9.—Section of Model with Screws of Varying Diameter but in Fixed Position.

might be tried from this fixed position, still leaving sufficient clearance from the tip of the screw to the side of the model with the larger diameters. Fig. 9 shows a section of the model with the fixed position and screws ranging from 4 in. to 8 in. in diameter. Fig. 10 shows the results obtained with these different diameters on the model of ·65 block. These results indicate that increase in wake followed increase in diameter of screw. Now this result is due to the position and not to the diameter. If the same tip clearance from the hull had been chosen instead of varying clearances, the results might have been entirely different. The closer a small propeller is to the hull the larger the wake will be.

The wake pervading a screw is not uniform over the disc of the screw. The measurement of the forward velocities of the streams in the region of a screw has been undertaken on several occasions.

Mr. G. Calvert read a paper to the Institution of Naval Architects in 1893, "On the Measurement of Wake Currents." Rear-Admiral Taylor described his wake meter tube in his paper, "Calculations for ship forms, &c.," read to the San Francisco International Congress in 1915, and Messrs. Walker and Cook gave a sketch showing the wake distribution obtained on a model of the *San Fernando* to the Institution of Naval Architects in 1921.

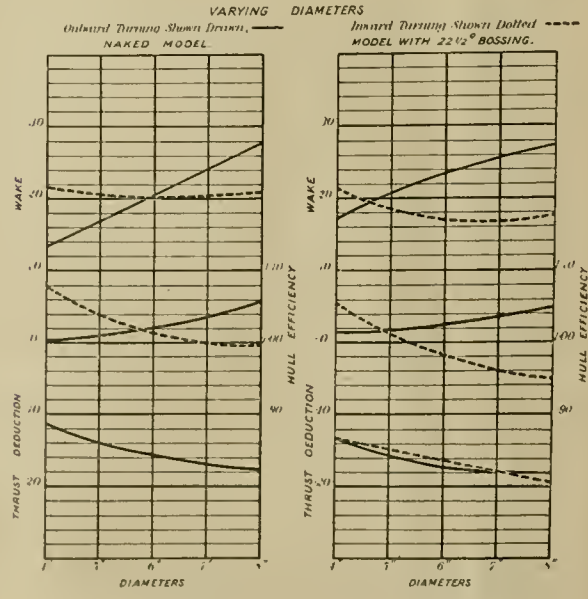


Fig. 10.—Model Results with Screws of Varying Diameter.

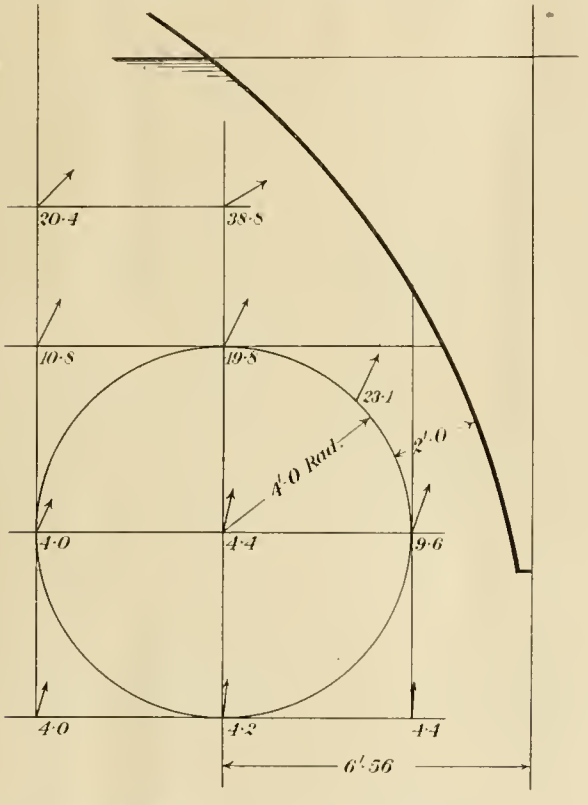
Fig. 11 shows a section in the region of the screws of a fine model tested at Washington, and Fig. 12 the wakes given for the *San Fernando* in the paper referred to.

It will be seen, if reference be made to Fig. 11, that the wake becomes more intense the closer the side of the model is approached.

(The values of "*w*" given on Figs. 11 and 12 are expressed as fractions of the speed of the ship (Taylor's method). Were these converted into Froude's terms, the values would be much higher.)

Seeming Contradiction in Luke's Results.

It has already been suggested that the transverse position of the screws (*see* Fig. 9) had an important bearing on the wake values obtained with the different diameters in Luke's experiments. With the ·65 block coefficient model increase in diameter gave increase in wake; with the ·75 block model increase in diameter gave decrease in wake. This difference in result is very probably due to the fact that with the finer model, the length of bossing would be much greater than with the fuller form, therefore the screws in the former would be longitudinally further away from the intense wake near the skin of the model. From this consideration it appears probable that less correction should be applied to the wakes obtained with the full model for transverse position that might be necessary in the finer form.



FIGURES SHOW AXIAL VELOCITIES OF WAKE AS PERCENTAGES OF SPEED OF SHIP

Fig. 11.—Wake at Propeller of Fine Model tested at Washington.

Diameter in Screw in relation to Thrust Delivered.

From the above observations it is clear that the value of the wake fraction is dependent on (*a*) fullness of ship; (*b*) angle of bossing; (*c*) on position of screw. It has been shown, also, that with increase in fullness of ship the effect of the angle of bossing becomes less pronounced. It may be possible to arrive at some expression which would give approximate values for wakes taking all these variables into consideration, but the writer can at present suggest no such solution.

In Fig. 8 it is evident that the effect of size of screw in relation to the thrust delivered is a much more important factor than the angle of bossing. This point yields to investigation. The calculation which follows assumes that the wake

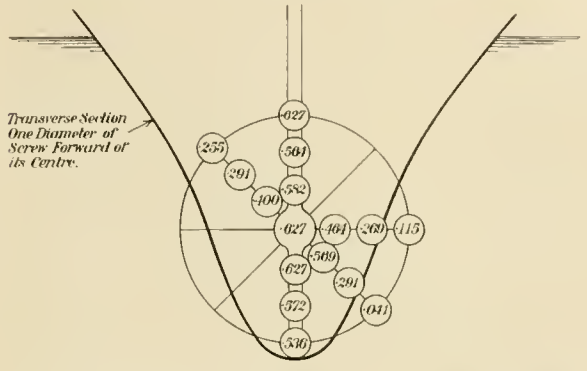


Fig. 12.—Wake at Propeller of Model of "San Fernando."

may be dependent on the thrust delivered, the size of the screws, and on the speed of the ship. The thrust delivered has been estimated for the *Sueeia*, and for Luke's D and E models. In order to get the values into reasonable figures the thrust in lbs. is taken; the speed in knots; and the diameter in feet.

Case.	Diameter in feet.	V. in knots.	Estimated thrust in tons = T (one screw).	$\frac{T \times 2240}{D^2 \times V^2}$	"*w*."
Suecia	10	11	10 (*b*) analysis	1·85	·69
Luke's D model	10	13·33	15	1·89	·69
Do.	12	13·33	15	1·31	·45
Do.	14	13·33	15	·96	·37
Luke's E model	14	12	13·5	1·07	·37

The wake values have been plotted (*see* Fig. 13) on a base of thrust in pounds divided by the speed^2 and diameter^2. They are found to be quite harmonious, and suggest that for full twin-screw vessels with flat bossings which are being driven with small propellers revolving at a high rate of revolutions, the question of diameter in relation to the thrust to be given has a determining influence on the wake value.

For vessels under a basic value of unity and with screws of normal diameter, the wakes shown on Fig. 8 should be adopted.

Propeller Design.

Having thus arrived at some definite conclusions with regard to the wake, which, after all, is probably the most important point to determine if experimental propeller diagrams are to be used for the determination of dimensions, the general question of this determination may be briefly considered.

Take the case of a twin-screw motor ship, 365 ft. in length; 50-ft. beam and 23-ft. service draught, and of 9,350 tons displacement, having a speed of 11 knots, with fan-bladed propellers. If no results of model experiments with such a vessel are available, refer to Fig. 3 (page 23). There it is indicated that

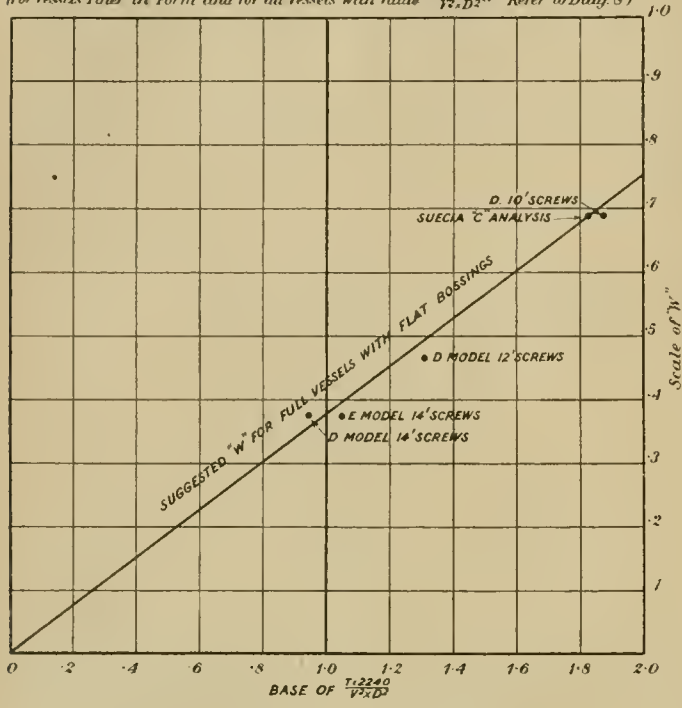

SUGGESTED VALUES OF WAKES FOR FULL TWIN SCREW VESSELS WITH FLAT BOSSINGS.
(For Vessels Finer in Form and for all Vessels with Value T×2240/V²×D² < 1 Refer to Diag. 8)
D. 10' SCREWS
SUECIA 'C' ANALYSIS
D MODEL 12' SCREWS
E MODEL 14' SCREWS
D MODEL 14' SCREWS
SUGGESTED "w" FOR FULL VESSELS WITH FLAT BOSSINGS
Scale of "w"
BASE OF T×2240/V²×D²
0 ·2 ·4 ·6 ·8 1·0 1·2 1·4 1·6 1·8 2·0
1·0 ·9 ·8 ·7 ·6 ·5 ·4 ·3 ·2 ·1

Fig. 13.—Wake as Calculated.

the E.H.P. will be approximately 1,120, and the resistance 14·8 tons, and the probable thrust per screw

$$\frac{14{\cdot}8 \times 1{\cdot}30}{2} = 9{\cdot}6 \text{ tons.}$$

Froude's 1908 propeller curves, Fig. 1, will be used. In order to arrive at the dimensions, it is necessary to know the wake, so that the speed corrected and the H, or thrust horse-power, can be determined. But by the considerations which have already been discussed, the diameter must be approximately known before the wake can be determined. In order that this may be accomplished, Fig. 14 has been constructed, which gives the approximate diameter for propellers of unity pitch ratio for stated E.H.P. per screw and

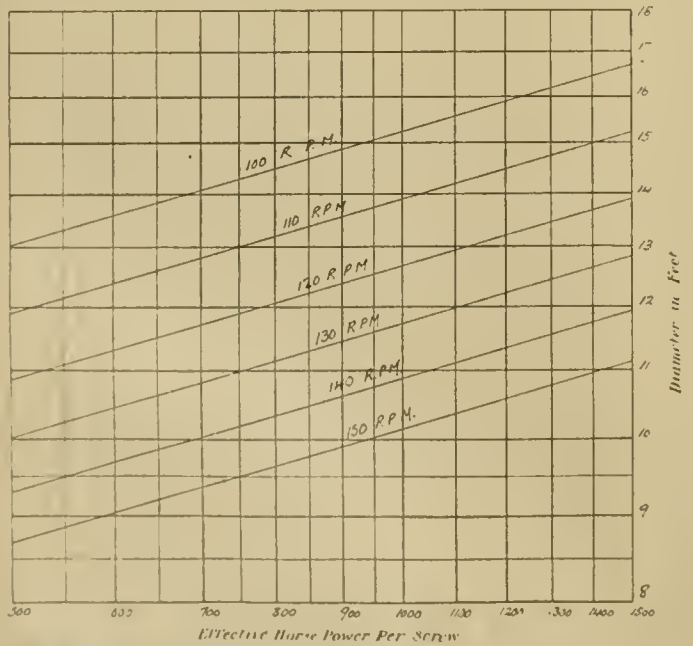


Fig. 14.—Diagram giving Approximate Diameter of Propellers for different Horse-powers and Revolutions.

number of revolutions. From this diagram it appears that the approximate diameter will be 9 ft. 6 in. The value of $\frac{T \times 2{,}240}{D^2 V^2}$ becomes $\frac{9{\cdot}6 \times 2{,}240}{90 \times 121} = 1{\cdot}97$. Refer now to Fig. 13. This shows that the approximate "w" will be ·75, the V_1 (or speed corrected) becomes therefore $\frac{11}{1{\cdot}75} = 6{\cdot}3$ knots. and the H (or thrust horse-power) $\frac{9{\cdot}6 \times 6{\cdot}3}{{\cdot}1455} = 415$. It was shown earlier in the article that for purposes of design this H should be increased by 10 per cent., therefore H becomes 457.

Froude's $C_A = \frac{R^2 H}{B V_1^5}$, R being $\frac{\text{revs. per min.}}{100}$, and B = ·115 assumed. With $R^2 = 1{\cdot}96$; H = 457; B = ·115 and $V_1^5 = 10{,}000$,

$$C_A = \frac{1{\cdot}96 \times 457}{{\cdot}115 \times 10{,}000} = {\cdot}778.$$

At this C_A value the maximum efficiency is indicated by screws of ·8 pitch ratio.

Froude's $C_o = \frac{H}{B D^2 V_1^3}$ and $D^2 = \frac{457}{{\cdot}115 \times C_o \times 250} = \frac{15{\cdot}85}{C_o}$.

At the given C_A value the C_o proper to different pitch ratios are noted.

Pitch Ratio.	C_o.	Diameter in ft.	Pitch (effective) in ft.	Pitch (face) = Pitch effective / 1·1	Efficiency.
·8	·138	10·7	8·55	7·77	·57
·9	·152	10·2	9·17	8·35	·54
1·0	·166	9·75	9·75	8·85	·50

This result indicates that the desirable screw would be about 10·5 ft. in diameter. Using this diameter for the "w" determination, the new "w" becomes ·55; V_1 becomes 7·1; H becomes $\frac{9{\cdot}6 \times 7{\cdot}1 \times 1{\cdot}1}{{\cdot}1455} = 515$.

$$C_A = \frac{1{\cdot}96 \times 515}{{\cdot}115 \times 18{,}000} = {\cdot}487 \; ; \; D^2 = \frac{515}{{\cdot}115\, C_o\, 357} = \frac{12{\cdot}55}{C_o}.$$

Pitch Ratio.	C_o.	Diameter in ft.	Pitch (effective) in ft.	Pitch (face) = Pitch effective / 1·1	Efficiency.
·8	·104	11	8·8	8·0	·60
·9	·115	10·45	9·4	8·55	·58
1·0	·126	10	10	9·1	·55

The particular ship to which the above particulars apply was fitted with propellers 10 ft. 6 in. diameter and 8 ft. 6 in. pitch. The above particulars for the ·9 pitch ratio propellers almost exactly agree with those of the actual screw.

The above case is very similar to that of the *Suecia*. Take, as another example, a twin-screw motor ship of 20,000 tons displacement and 12½ knots speed: approximate effective horse-power being 2,500, the probable thrust per screw being 19·5 tons, 115 r.p.m., 3-bladed screws. The expanded surface will be approximately 60 sq. ft., the approximate value

of diameter with screw of unity pitch ratio being 13·5 ft. Assume diameters of 15 ft., 14 ft., and 13 ft.

With diameter of 15 ft. base for "w" =

$$\frac{19\cdot5 \times 2{,}240}{225 \times 156} = 1\cdot245 \text{ and } \text{"}w\text{"} = \cdot43$$

with

$$\text{"}w\text{"} = \cdot43 \quad V_1 = \frac{12\cdot5}{1\cdot43} = 8\cdot75 \; : \; V_1^3 = 670 \; : \; V_1^5 \; 51{,}200$$

$$H = \frac{19\cdot6 \times 8\cdot75 \times 1\cdot1}{\cdot1455} = 1{,}295 : R^2 = 1\cdot32 :$$

$$B = \cdot105 \text{ (3-bladed elliptical } \cdot4DAR).$$

Then

$$C_A = \frac{1.32 \times 1{,}295}{\cdot105 \times 51{,}200} = \cdot318 : C_a = \frac{1{,}295}{\cdot105 \times 225 \times 670} = \cdot082.$$

At which C_A, C_a the pitch ratio is ·85, the pitch effective becoming 12·75 ft. and the face pitch $\frac{12\cdot75}{1\cdot1} = 11\cdot6$ ft.

Since a reduction in the diameter to either 14 ft. or 13 ft. would bring about an increase in pitch ratio with an accompanying decrease in efficiency, there is no need to pursue this case further.

Limiting Pitch Ratio.

It has been found that propellers of very low pitch ratio do not seem to perform well on service. The trial results of several vessels fitted with screws of very low pitch ratio have been given on several occasions by Rear-Admiral Dyson. It is just possible, although the results of the *Suecia* do not seem to indicate that this critical pitch ratio has been reached, that any further diminution might lead to inferior performances. Knowing this, one might be inclined to recommend, in cases like the above, the adoption of screws with pitch ratios nearer unity, although experimentally these do not offer as high an efficiency as those of lesser pitch.

Amount of Surface.

From the examination of the amount of surface given to screws, there seems to be no definite law followed by designers. In the case of fast destroyers and cruisers where cavitation may be encountered, certain limiting pressures are frequently adopted. When slow speed ships' screws are being considered, less definite limits are in general use. The writer has arrived at the conclusion that good practice would be to give sufficient area to allow a pressure of 4 lb. per square inch expanded surface for propellers exerting a total thrust per screw of 10 tons; 4½ lb. per square inch for a total thrust of 15 tons; and 5 lb. per square inch for a total thrust of 20 tons.

In the example worked out above, the thrust for one screw was 9·6 tons; the appropriate surface would therefore be $\frac{9\cdot6 \times 2{,}240}{4\cdot46 \times 144} = 33\cdot4$ sq. ft.; the actual surface was 36 sq. ft.

In conclusion, the writer is greatly obliged to Mr. Blache for the publication of the results of the *Suecia's* trials, for the analysis which these suggested has made possible a better correlation between actual and experimental results.

NEW TWIN-SCREW ITALIAN LINER "CONTE ROSSO."

The twin-screw liner *Conte Rosso*, which ran trials last month, was designed, constructed and engined by William Beardmore & Co. Ltd., in their Naval Construction Works, Dalmuir, for Lloyd Sabaudo, of Genoa, for their passenger and cargo service between Italy and the Americas. She has the following dimensions :—

Length, overall	591 ft.
,, on l.w.l.	580 ft.
,, b.p.	570 ft.
Breadth, moulded	74 ft.
Depth, moulded to shelter deck	40 ft.
Load draught	26 ft.
Gross tonnage (about)	18,000.
Speed on service (knots)	18½.
Number of passengers and crew (about)	2,850.

The vessel has a straight stem well raked forward, and elliptical stern, the lower portion below the water line being bossed out to accommodate the underwater steering gear.

There is accommodation for 208 first-class passengers, 268 second-class, 1,890 third-class, and officers and crew numbering 442.

The main generators are three 160-kw., 110 volt, geared turbo-dynamos, and there is an emergency oil-driven generator of 35 kw. The *Conte Rosso* is remarkable in regard to its lighting as being the first merchant vessel to which the Admiralty practice of fitting a ring main has been applied. The covering for the main ring cables was specially manufactured for this vessel. The total number of lights is 3,150 and the total horse-power required for the various motors is 510. All the larger machines are automatically controlled, which obviates the necessity for skilled labour for their supervision.

The propelling machinery (*see page* 103) consists of two sets of steam turbines of the Parsons impulse and reaction type, each driving—through double-reduction gearing—a common gear wheel mounted on the propeller shaft. The gearing consists of the usual interleaf design of double reduction, both first and second pinions being of 3 per cent. nickel steel manufactured in the Beardmore Steel Works at Parkhead, Glasgow. All the pinions and wheels were cut in the builders' marine engineering shops at Dalmuir. William Beardmore & Co.'s long experience of gearing, combined with the highly successful results attained by heavily-loaded gears installed by them in transatlantic ships, has been of considerable value in this instance, the sets in question giving entire satisfaction at their designed shaft horse-power output of 11,000 each at 92 r.p.m. In each low-pressure turbine casing is an astern turbine to give ample manœuvring power. The turbines are designed to operate with 150 lb. of steam pressure and 220° Fahr. superheat at the stop valves. Where subject to superheated steam the turbines are of cast steel and the blades of special phosphor bronze to cope with the high temperatures to which they are subjected. The designed speeds are 2,950 r.p.m. for the high-pressure turbines, and 1,686 r.p.m. for the low pressure, and these speeds were exceeded to the extent of 20 per cent. when tried under steam in the shops. Racing (*e.g.*, due to racing of the propellers) is prevented by the latest type of Cockburn-Aspinall governor, which also operates to shut off the steam supply of the failure of the forced lubrication system or drop in the oil pressure below a certain limit.

The manœuvring platform is at the main turbine level and not sunk to a flat slightly above the tank top as has been the practice in so many recent ships. This enables the engineering staff to have complete survey and immediate access to running parts without leaving the control wheels.

Steam is supplied by six double-ended and two single-ended boilers of the cylindrical type manufactured in the builders' marine engineering shops at Dalmuir. The former are 22 ft. long, the latter 11 ft. 3 in., with a diameter of 16 ft. 3 in. in each case. The boilers have Howden's forced draught and Robinson smoke-tube superheaters. They are primarily designed to burn oil on the Wallsend-Howden system, but are capable of rapid conversion to coal firing in case of necessity.

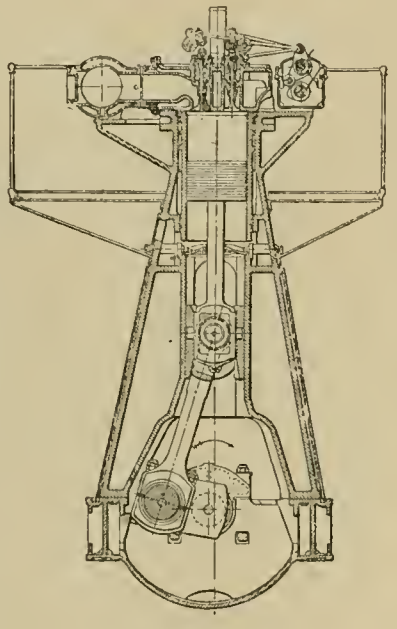
There is a well fitted-out workshop with motor-driven lathe, drilling machine, grindstone, &c., enabling the ship to be independent of shore resources for small repairs.

The equipment of recording and measuring apparatus is unusually comprehensive, including Pneumercators, "long-distance" thermometers, torque-measuring apparatus, tachometers, &c., to ensure that complete knowledge of the conditions prevailing can be obtained at a glance.

DEVELOPMENTS IN THE DESIGN OF MARINE OIL ENGINES.—I.

Different Types—Burmeister and Wain—Vickers—North British Diesel—Tosi—Werkspoor—Doxford—Cammell Laird-Fullagar.

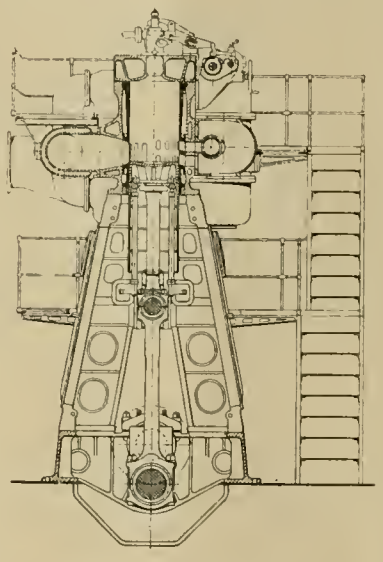
The development of the present designs of modern oil engines has been very largely influenced by the known existing successful types of reciprocating steam engines, and this feature largely predominates in present-day designs, particularly with four-stroke engines. In the case of steam plant developments have generally taken the line of improvement of the original fittings and of accessories, tending to raise the efficiency of the combined plant. The Diesel engine, on the other hand, offers considerably more scope for inventive ability and latitude in the matter of design on account of the whole of the power-producing plant being self-contained, and it is interesting to compare the various designs which have been evolved. On account of its comparative simplicity of design the four-stroke engine was largely adopted by the pioneers of marine oil engines, since the two-stroke engine, with its additional problems of heat stresses and scavenging, called for considerable experiment and research, with the consequent result that the preponderance of oil-engined vessels are fitted with engines of the four-stroke type. The two-stroke engine, however, is now becoming more popular, and British manufacturers are now turning their attention more to this type.



Tosi Type—Four-stroke.

Dealing with the better-known types of oil engines, the four-stroke engine of Burmeister and Wain's design is probably the best known in the mercantile marine service, having been fitted in practically every type of vessel, and the latest venture of this firm in satisfactorily completing a long stroke engine is one which will satisfy a long-felt want in the marine service. The bedplate, connecting rod and crosshead follow steam engine lines. "H" pattern columns are placed athwartship on the bedplate, through bolts being fitted between the latter and the tops of the cylinders, thus relieving the columns and cylinders of stresses due to internal pressure. The crankshaft is of the built-up pattern. The piston is hollow, of box section, and is arranged for water cooling by means of trombone pipes which pass through glands in a cast tray. The cover is of deep section, and carries the usual valves, the principal point of interest being in the fact that, contrary to usual practice, the fuel valve opens inwards. The fuel pumps, one of which is arranged for each cylinder, are grouped together, controls being fitted to the suction valves, which are also operated by the governor gear. The camshaft is fitted at the bottom of the cylinders, and long push rods are required to operate the valve levers, which are mounted on a fulcrum shaft supported by pillars secured to the cover. Power for reversing is obtained by a servo-motor, which operates a manœuvring shaft for lifting the rollers clear of the camshaft, and slides the latter along for reversing, the manœuvring shaft returning the rollers to the camshaft. The fuel is injected into the cylinders by means of blast air supplied by a three-stage air compressor driven by the crankshaft at the forward end of the engine.

Of the purely British four-stroke engines, Vickers can claim to be the pioneers. Although comparatively new to mercantile marine work, it is claimed that close upon half a million horse-power to their designs have been made in large units, principally for the British submarine service, which places them in the front rank of Diesel engine manufacturers. Generally, the design of the engine is similar to the foregoing. The crankshaft is solid, the whole of the cylinders being bolted together to form a stiff entablature, the centre gap being bridged by a distance piece. The camshaft is fitted at the top of the engine, and directly operates the valve levers through rollers. Hand levers are fitted for controlling the engine, instead of the usual hand wheels. Rapid starting is claimed due to the fact that fuel is admitted to the cylinders during the period the air starting valves are open, means being provided for automatically cutting off air starting as the fuel lever advances to full power position. Perhaps the most interesting feature of this engine, and one that has given rise to considerable discussion, is the method of fuel injection. This is accomplished by raising the fuel pressure to about 3,500 to 4,000 lb. per sq. in. by a high-pressure pump. This pump discharges to a fuel rail running the full length of the engine, which is directly connected to each fuel valve, in which there are a number of very fine holes through which the fuel is forced, atomisation of the oil immediately taking place. The use of this system eliminates the usual blast air compressor.



Sulzer Type—Two-stroke.

The four-stroke engine made by the North British Diesel Company is, in appearance, very similar to those described above, except that the cylinder and its supports are somewhat special. The cylinder jackets are inserted into an entablature which is supported and held by steel columns, which pass down to the bedplate. The crosshead guides are carried by cast-iron A columns, which also serve to carry the thrust due to the angularity of the connecting rod. Another somewhat unusual feature is the method of reversal, which is effected by removing the camshaft from the rollers, sliding the camshaft to its astern position, and replacing the camshaft in the reverse position, the operation being effected by a layshaft worked through rack and pinion by means of a servo-motor. Apart from these particular features, the engine calls for little further description beyond that of the two previous types.

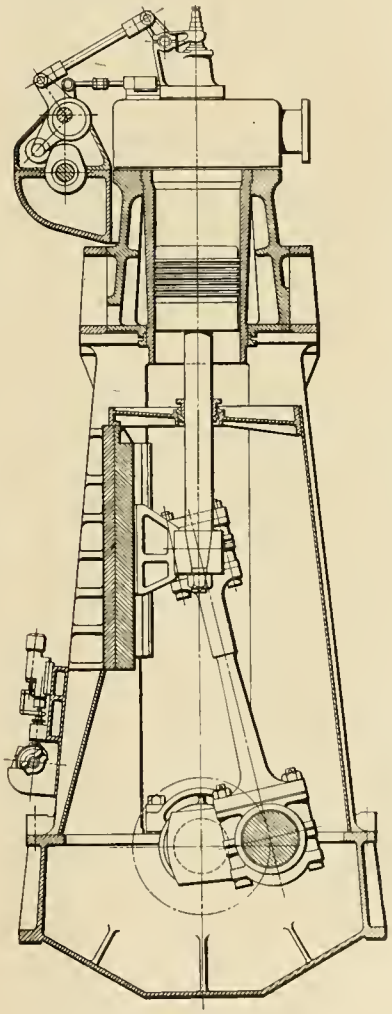
The Tosi engine, of which a section is shown, bears a great similarity to the standard type, the outstanding feature being undoubtedly the valve gear. In place of the separate inlet and exhaust valves in the cover, two combined inlet and

exhaust valves are fitted, operated by one lever only, a semi-rotary valve serving to change the functioning of the valve. The fuel valve also is of somewhat novel design, the lever acting on a fulcrum lever through a ground vertical spindle arranged with a seat at its lower end to prevent leakage, and so fitted that it can be readily ground in without dismantling of gear. In the reversing gear, the rollers only are moved from the ahead to the astern cams, the power being derived from an electric motor. Other points of special interest in this design are the heavy flywheel adopted as standard, and the very thick piston crowns. In some of the older designs, the low-pressure cylinders of the air compressors fitted for blast air were arranged for air starting, but this system has now been abandoned, and the recent engines conform to standard practice in this respect.

Mention of four-stroke engines would scarcely be complete without reference to the pioneers of this class of engine in merchant vessels. Werkspoor were responsible for the engines fitted in the *Vulcanus*, the first ship of ocean-going size fitted with Diesel engines, and their experience with this and later craft have given them very valuable experience from which they have undoubtedly benefited. The modern design of Werkspoor engine more or less resembles the original design in outline form, which is based on the principles proved by steam engine practice. The main features calling for note are perhaps the special arrangement of the cylinder and cover, which are cast together and fitted into an entablature, the claim being that better cooling of these important parts can thus be obtained. The entablature is supported and secured by steel columns which are braced by diagonal stays. Two fuel pumps are fitted, one acting as standby, the action of which is to pump fuel into a reservoir free to move in a vertical direction. The reservoir is counterbalanced, and is arranged to cut off the fuel pump suction valves when the fuel supply reaches a predetermined amount, the fuel being fed to the fuel valves by gravity. A governor is fitted to the fuel piping between the reservoir and the fuel valves in the covers. The camshaft remains stationary during reversing, the valve levers being mounted on eccentrics which are slightly askew, and so arranged that during a movement of 180 deg. the levers are raised from one set of cams and lowered on to the other. The camshaft drive is taken from a cranked layshaft through vertical coupling rods, the layshaft deriving its motion by means of spurs from the crankshaft. The blast air is supplied by the usual three-stage compressor driven by the engine.

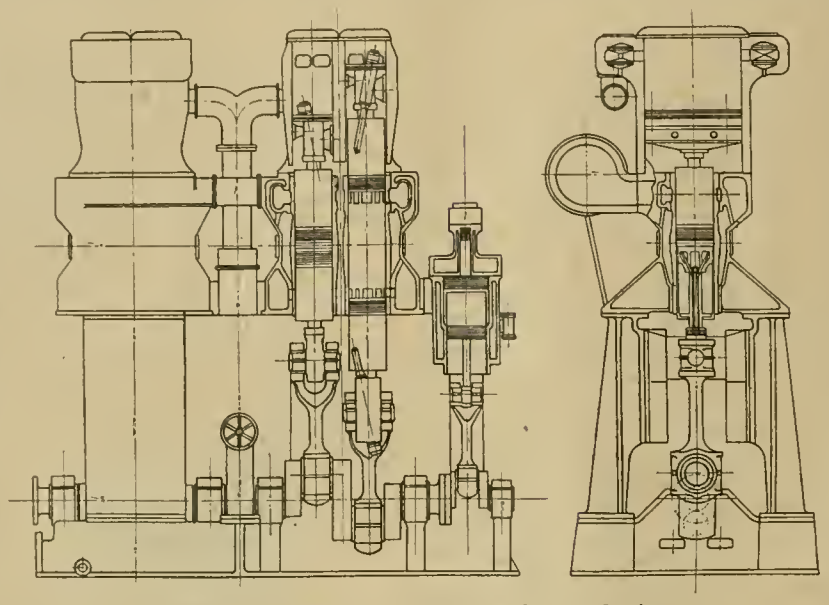
Generally speaking, it is in the case of two-stroke engines, where there are considerably greater difficulties to be surmounted, that some ingenuity has been displayed, although in the case of the best-known two-cycle engine, the Sulzer, of which a sectional view is shown, the general arrangement follows the orthodox line of the steam engine with the bedplate, cast A columns, connecting rod and crosshead. The cylinder cover is reduced to its simplest terms in this type of engine by the fitting of a uniform casting free to expand equally in all directions, an important factor in two-stroke engines, where heat stresses are very severe. A central hole is cast in this cover which carries a cage into which is fitted the fuel, air starting and relief valves. The valve gear comprises two sets of cams and one set of eccentrically mounted levers, one end of the latter being fitted with double rollers. Reversing is effected by the usual servo-motor gear operating a layshaft which brings the appropriate rollers in engagement with the ahead or astern cams. A double-acting scavenging pump is arranged, driven by an extension of the engine crankshaft, supplying air through a double row of ports cut circumferentially in the liner, the lower row of ports being controlled by the piston and the upper row by a rotary valve, which admits the scavenge air when the exhaust pressure is reduced to approximately the scavenge pressure, and continues after the exhaust ports are closed, until the piston cuts off the supply, thus making for efficient scavenging. The fuel is supplied to the cylinders by means of a pump arranged with one plunger for each cylinder, the supply being adjusted by the timing of the suction valves. The fuel is blown into the cylinder by a three-stage air compressor of the usual type driven from an extension of the engine crankshaft.

An interesting comparison is offered to this engine and between themselves by the two-stroke opposed piston engine of the Doxford & Camellaird-Fullagar types. These engines, while operating on the same principle in so far as the fuel is injected between two pistons moving in opposite directions, transfer the power to the crankshaft by entirely different methods. In the case of the first-named, the power from the lower piston is transferred direct to the crankshaft through the usual piston and connecting rods, the upper piston being connected to a crosshead at the top of the engine, which is attached to the crankshaft by means of vertical rods, one on each side of the cylinder, the arrangement involving three cranks on the crankshaft for each cylinder. In the Camellaird-Fullagar engine, of which a section is illustrated, the cylinders are erected in pairs, two cranks at 180 deg. being fitted for each pair of cylinders, no intermediate bearing being fitted between the two cranks, thus offering a simplification of design of crankshaft as compared with the Doxford engine. Another very striking difference is the method of fuel injection, the Camellaird-Fullagar adopting the air injection system claimed by some authorities as the true test of the pure Diesel, the Doxford engine following the solid injection system pioneered by Vickers. The compression adopted in the latter engine is of the order of about 300 lb. per sq. in., and the pistons are accordingly arranged with an uncooled top on the lines of the semi-Diesel hot bulb, the heat of compression not being sufficient in itself to ignite the fuel. The engine cannot be started from cold without pre-heating from some external source, and in the present design this is arranged to be effected by steam from a small donkey boiler. This is somewhat disadvantageous where all electric auxiliaries and electric heating are adopted. No cylinder covers are required with either of these designs, while in both cases scavenging takes place through holes cut circumferentially at the lower end of the cylinder, the exhaust ports being arranged similarly at the top, thus giving effective scavenge. A special point with regard to the Doxford engine is the very high pressures of the fuel, which works up to about 8,000 to 10,000 lb. per sq. in., and as the pumps are glandless, very careful workmanship is required to ensure their satisfactory behaviour.



Vickers Type—Four-stroke.

While in the ordinary Diesel engine advantage may be taken of the latent heat in the exhaust by passing same through a specially arranged exhaust heat boiler, a considerable advance upon this arrangement is claimed in the Still engine. This engine combines the principles of the oil engine with those of the steam engine, the pistons being double acting. The upper end of the piston is operated on the two-stroke Diesel principle, and the lower end by steam raised in a special boiler by the exhaust gas heat; the cooling water for the jackets is always circulating at the same temperature, which is regulated by the boiler pressure. In order to make the fullest possible use of the steam generated, both high and low-pressure cylinders are arranged in a multi-cylinder engine. The special feature of this engine is the absence of valve mechanism in the Diesel end of the cylinder, the only valve fitted being the fuel valve, which is timed by the fuel pump.



Camellaird-Fullagar Two-stroke Opposed-piston.

The fuel is injected on the solid injection system. The exhaust and scavenge are arranged by ports cut in the cylinder. Starting and reversing operations are arranged on the steam side of the piston.

It is not possible here to deal with more than the principal points in several of the leading designs, but it is sufficient to bring out with some force the considerable diversity of opinion with regard to the important matters of design. While there is room for all these, the ultimate aim is the engine which will give the highest possible thermal efficiency, and with this end in view, it behoves manufacturers to assist this line of progress by co-operation, more particularly with regard to difficulties experienced, as undoubtedly a considerable amount of overlapping occurs which could thus be easily avoided. On the other hand, shipowners will best serve their own interests in encouraging the efforts of the manufacturers by the fitting of oil engines into their vessels, as only by actual sea experience will the outstanding types prove themselves, and lead the way to finality in oil engine design.

(*To be continued.*)

NEW WHITE STAR LINER "HOMERIC."

The latest addition to the Southampton-Cherbourg-New York service of the White Star Line is the *Homeric*, which sailed on February 15 from Southampton, on her maiden voyage. This vessel, which was built by F. Schichau, Danzig, and launched on December 17, 1913, was to be the largest vessel in its owners' fleet—the Norddeutscher Lloyd—and was christened *Columbus*. The second and third largest vessels of this fleet, in 1913, were the *George Washington* and the *Kronprinzessin Cecilie*. The following table shows a comparison between these vessels :—

	Columbus (*Homeric*).	*George Washington.*	*Kronprinzessin Cecilie.*
Length, extreme	774 ft. 3 in.	722 ft.	705 ft. 3 in.
Breadth, moulded	83 ft.	76 ft.	72 ft.
Depth to main deck	53 ft. 9 in.	53 ft. 6 in.	52 ft. 6 in.
Displacement	42,000	37,000	27,000
Gross tonnage	35,000	25,570	19,503
Engines	Triple expan. (8 cyl.)	Quad. expan. (8 cyl.)	Quad. expan. (8 cyl.)
I.H.P.	30,000	21,000	45,000
Speed	20 knots.	18 knots.	23·5 knots.

Owing to the outbreak of the war the vessel was not completed, and was eventually purchased by the White Star Line from the Reparations Committee and re-named.

The vessel has a cargo carrying capacity of about 10,000 tons, and accommodation is provided for 529 first, 487 second and 1,750 third-class passengers.

With the exception of the dining saloon, which is on the main deck, all the first-class public rooms, which consist of the lounge, music room, reading and writing room, smoking room and drawing room, are situated on the boat deck, a noticeable feature of all these rooms being their height and the large windows and wells.

The propelling machinery was supplied by the builders, F. Schichau, Elbing, and consists of two sets of triple-expansion engines having cylinders 50⅔ in., 86⅗ in., two 96½ in. and 70 in. stroke. Steam is generated by 12 coal-fired boilers, fitted with superheaters and Howden's forced draught installation, and are designed for a working pressure of 210 lb. per square inch.

At the invitation of the White Star Line a company of about 550 journeyed to Southampton by special train to view the *Homeric*, and were afterwards entertained to luncheon on board in the first and second-class dining saloons. Mr. Harold A. Sanderson, Chairman of the White Star Line, presided at the luncheon.

Mr. Harold Sanderson, in proposing the toast of the "Trade and commerce of the port of Southampton," said the occasion reminded him of a similar event which occurred 15 years ago; this was prior to the sailing of the *Adriatic* from Southampton, which was the first White Star liner to use that port. Southampton was, at that time, considered a fine port, and he was glad to see that the authorities were anxious to maintain that description and were making the modifications found necessary to accommodate the largest vessels now built. Referring to their latest acquisition, the *Majestic*, he mentioned that there was no dock in Britain large enough for her accommodation, but he was pleased to state that the authorities were in communication with the Admiralty, and such a dock would soon find its home at Southampton.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

German Standard Ship Details.

The Handelsschiff-Normen-Ausschuss, which is the German committee engaged upon the standardisation of ship details, publishes its recommendations as a supplement to the fortnightly shipbuilding journal *Werft, Reederei, Hafen*. In the recent numbers particulars of the following have been given; Ringbolts (various) for accommodation purposes; deadlight chains and stays; weather board clamps; cabin door hinges (three series), hand rail stanchions (6 series with gas pipe, wood and chain hand rails). The particulars are very complete; the drawings are large and clear, each sheet being 13¼ in. by 9½ in. The sheets are also issued separately by the publishers, Julius Springer (Berlin W.9, Link Str. 23/24). at 15 marks per sheet exclusive of postage.—*Werft, Reederei, Hafen*, Supplements, January 7 and 22, February 7, 1922; 12 sheets.

Crude Oil Motors for Fishing Vessels.

The motor fishing industry is increasing in the North Adriatic and many existing fishing craft are being converted to motor craft. Full details of such a conversion on the *Giulio Cesare* (locally termed a *baggozzi*) are given. The motor is a 24 h.p. "Satima" crude-oil hot-bulb type working at 450 r.p.m., and is fitted amidships in order to reduce the rake of shaft as much as possible. The propeller shaft is of muntz metal and is connected by a friction coupling to the motor. The propeller, which is bronze, is 2·35 ft. diam. with 2·15 ft. pitch. On trial a speed of 7¾ knots was obtained, and when trawling a speed of 3 knots was easily attained. An average fuel consumption of ·55 lb. per b.h.p.-hour shows that the propulsion is quite economic. Special motor fishing boats are being built of more suitable underwater form than those converted, but of equal handiness of working in order to attract the fishermen to the newer class of vessel. A number of detail diagrams and photographs make the article complete.—*Der Kleinschiffbau*, January 28, 1922, page 23; 2 pages; 7 ff.

Mechanical Computation of Cutting Speeds, &c.

In assessing the time allowed for various cutting operations much mental effort can be saved by means of specially constructed mechanical means to computation. Such aids are charts, alignment charts, slide rules, &c. The author especially considers the two latter. The former of these possesses many advantages, but because of a certain amount of drawing which they entail when being used, they are capable of some improvement when made on the slide rule principle. Here, instead of drawing cross-lines at acute angles in order to find the required solution, the scales themselves are slid by a link arrangement until the connecting line (technically called an isopleth) becomes horizontal and thus the reading is greatly simplified. Various problems in cutting speeds and times are worked out and show clearly the utility of the method. In addition, a special type of slide rule specially adapted for rate and weight calculations is described and illustrated in some detail.—*K. Gottwein, Werkstattstechnik*, February 1, 1922, page 65; 3½ pages; 11 ff.

Rebuilding the German Mercantile Marine.

The series of articles on this subject (*see* January Foreign Notes) has provoked criticism in German technical circles. The author's view that a double-bottom ship is less safe than a single-bottom ship proved the chief controversy. In this article Herr Stieghorst replies to his critics and his defence is interesting. The presence of the double bottom produces in the side plating heavy shearing stresses which are much above the elastic limit and result in permanent deformation of the material. The double bottom is not primarily a safety device but merely a container for water ballast. The present carrying of oil fuel in the double bottom is injurious to stability because of the free surface of the oil. The only advantage of the double bottom is to increase the vessel's draught in the light condition without appreciably increasing the stress coming on the bottom structure. Where, however, a deep tank is fitted the classification societies do not penalise this concentration of load for no additional strengthening of the bottom structure is required. Deep tanks could be fitted instead of the double bottom and thus the loss of cargo space, deadweight, accessibility, and initial stability associated with the latter could be eliminated. Further criticism was directed against the author's own criticism of the classification societies, and in his reply the author maintains that these societies have atrophied the technical design of ships' structures and again suggests that their functioning should be taken over by the State.—*J. Stieghorst, Schiffbau*, January 25, 1922, page 502; 4½ pages.

The Weight of Concrete Ships.

In order to examine the relative structural efficiency of concrete and steel ships several actual cases are considered and compared upon a basis of weight of respective hull per ton deadweight. The relative efficiency varies with the absolute size of ship. The most favourable comparison for sea-going vessels is for a deadweight of about 3,000 to 3,500 tons where the concrete hull weighs ·56 ton per ton d.w. and the steel hull ·36 ton, the concrete being thus 55 per cent. heavier than the steel. For smaller ships of about 1,000 tons d.w. the concrete hull is ·75 ton per ton and the steel ·42, the concrete in this case being 79 per cent. heavier. For the larger ships about 9,000 tons, the concrete compares still more unfavourably, weighing ·60 ton per ton as against ·31 ton in the steel hull and is thus 94 per cent. heavier. The figures given are of course average. The investigation is extended to river vessels, and for small craft of 300 tons d.w. the concrete absorbs ·50 ton and the steel hull ·35 ton per ton, the concrete being here 45 per cent. heavier. For 750 ton d.w. the concrete is ·41 ton against ·24 ton per ton in the steel and is thus 76 per cent. heavier. In larger vessels of about 1,800 tons the concrete becomes ·29 against ·14 ton per ton in the steel, *i.e.*, 107 per cent. heavier. As weight is of less importance in river vessels, the author considers that the future development of the concrete vessel will be chiefly in this class of ship. —*Dr. Commentz, Der Bauingenieur*, November 30, December 15, 1921.

Föttinger Hydraulic Transformers on the T.S. "Empress of China" (ex "Tirpitz").

Previous applications of the Föttinger gear are briefly discussed and the general particulars of the *Tirpitz*, now the *Empress of China*, are given in a number of diagrams and considerable detail. The gear was completed in 1912, and from that time until 1914 exhaustive tests were carried out. The vessel itself was not completed until January, 1921. A close examination is made of the possible sources of loss of efficiency in the Föttinger transformer, and as a result of a 14 days' continuous trial these losses were assessed as follows—hydraulic, 7·6 per cent.; mechanical, 3·6 per cent.; external, ·3 per cent., giving an overall efficiency of 88·5 per cent., these figures being based upon the 1912 trials. Subsequent modifications such as the utilisation of the transformer water as boiler feed water have increased this efficiency up to 90 per cent. and 91·5 per cent. The early trials showed that an efficiency of 85 per cent. was obtainable at 20 per cent. power and increased slowly to the maximum 88·5 per cent. at 7,000 h.p. and remained practically constant even past 12,000 h.p., *i.e.*, only a 3½ per cent. change in efficiency takes place in varying from 20 per cent. to full load. The chief advantage of the Föttinger lies in its reversibility and the resulting elimination of the astern turbines necessary in ordinary mechanical reduction gearing. No especial claim is put forward for the Föttinger. A bibliography of the subject completes the article.—*Bull. Tech. du Bureau Veritas*, January, 1922, page 1; 5 pages, 6 ff.

Standardisation of Ships' Details in Holland.

The standardisation of ship details is being at present considered by the leading maritime nations. In England the work is being done by the committee appointed by the British Engineering Standards Association (B.E.S.A.); in France by the Commission Permanente de Standardisation (C.P.S.); in Germany by the Handelsschiff-Normen-Ausschuss (H.N.A.), and in Holland by the Hoofdcommissie voor de Normalisatie. The German and French recommendations have already been published, and the Dutch commission have had these in mind in drawing up their own. In this issue the standard sheets of mitre and bevel wheels, bollards (vertical and inclined posts and cruciform), and conventional signs for such details as ventilators, accommodation items, doors, &c., are given, there being eight sheets in all. The design of the bollards recommended is

discussed. They agree with the French, but differ from the German in having a wider base. The position of the bolts is not specified. The scantlings of the posts are based on the breaking strength of the hawsers required by Lloyd's, &c., and the most suitable size of bollard is obtained by the same criterion. The complete particulars which are supplied over a considerable range of size make these sheets very valuable to the practical shipbuilder.—*Scheepsbouw en Scheepvaart*, January, 1922; 4 pages; 8 ff.

Auxiliary Sailing Vessels.

Interest in the fuel economy of sailing vessels with auxiliary motors is increasing. Some maintain that the motor should just be used for harbour work and calms and should be of low power, while others state that the ship should be made absolutely independent of wind and weather and a fairly high-powered and economical motor capable of driving the vessel at 6½ to 7 knots should be fitted. The Germanischer Lloyd consider, however, that such a vessel is no longer a sailing vessel, but a motor ship, schooner (&c.) rigged and must be constructed as such with consequent greater freeboard. For purposes of tonnage measurement the motor room must be considered as a main engine room. This type of ship can, however, be quite economically run. Details are given of such a vessel, the M.S. *Rebecca*, built by D. W. Kremmer, of Elmshorn. The principal dimensions of the vessel are as follows :—Length b.p., 107·5 ft.; beam m.d., 23·2 ft.; draught, 8·5 ft.; freeboard, 1·21 ft.; displacement, 440 tons; deadweight, 290 tons; fuel oil, 6 tons. A four-cylinder two-stroke Benz Diesel engine of 120 b.h.p. at 120 revolutions, with a fuel consumption of ·464 lb. per b.h.p.-hour, is fitted as main engine. An 8 h.p. motor compressor is also fitted. The whole installation has worked satisfactorily in service in the last six months. A motor winch and windlass on deck are adapted for sail hoisting purposes. The vessel's stability is very satisfactory, no ballast being required even in the light condition. A photograph, general arrangement and 'midship section plans are given with the article.—*Mau, Werft, Reederei, Hafen*, January 22, 1922, page 31; 2 pages; 3 ff.

Still Engine Trials.

The salient features of the Still engine, together with the results of recent English trials, are briefly discussed. The article then mainly concerns itself with the conclusions of an influential French committee whose function was in May last to report on the previous trials carried out by the Still Company. The committee ran a separate series of trials which verified in every respect those carried out by the Still Company. The results showed that the fuel consumption was almost constant at ·36 lb. per b.h.p.-hour for a considerable range each side of 80 per cent. load, and thus for a considerable range of load the thermal efficiency remained almost constant. A mechanical efficiency of 87·7 per cent. and an overall thermal efficiency of 33·6 per cent. was obtained, this latter value being higher than the usual type of Diesel two strokes which have approximately 32·5 per cent. efficiency. The mechanical efficiency can be easily increased to 90 per cent. These figures do not take into account the work done by steam, and when this is included the thermal efficiency is increased to 37·8 per cent. at full load, but at 80 per cent. load where the minimum fuel consumption is given the efficiency is 39·8 per cent., *i.e.*, approximately 20 per cent. better than the average two-stroke Diesel. Through better design of the steam part of the plant (which being experimental was merely temporary, and therefore comparatively simple), it will be possible to increase this advantage over the Diesel to 30 per cent. The committee record their satisfaction of the flexibility of the engine. A review of the various other general aspects and applications of the Still engine such as range of fuel, application to locomotives, &c., concludes the article.—*Dr. Frederic Schwers, Bull. Tech. du Bureau Veritas*, December, 1921, page 298; 4 pages; 3 ff.

Note on Stability at Large Angles.

Many ship casualties can be directly traced to the lack of adequate stability, and it is imperative that all projected vessels should be carefully examined in this respect. The accident to H.M.S. *Captain* in 1870 first directed attention to the importance of freeboard and the necessity of examining the vessel's stability at large angles. This has resulted in the two present, but distinct investigations, the metacentric diagram and the curve of the statical stability. This latter is capable of further extension when the two diagrams are combined, and instead of the righting arm being plotted upon a base of angles, righting arm divided by the size of the particular angle is plotted upon that base. This curve lends itself much better to approximate calculation, and formulæ are given for the average type of merchant ship. The complexity of the question of approximate stability itself explains why the classification societies have not attempted to frame regulations for its control. The author suggests that one of the first steps towards making control possible would be the adoption by all shipbuilders of a standard method of estimating the vertical position of the vessel's centre of gravity. The method proposed is ingenious and is based upon the well-known Dewey systems of literature classification. The hull weight is subdivided into three main divisions :—

1. Weights of important influence on the centre of gravity.
2. Weights proportionately more or less constant, easy to determine, but of little influence on the position of the centre of gravity.
3. Weights not proportionately constant, difficult to determine, but still of little influence on the position of the centre of gravity.

Numbers are then assigned to the main divisions of the equipped weight and range from 1 to 9. A second similar series is assigned to each stage of progress such as design, launching, delivery, &c. A third series represents the degree of influence on the position of the centre of gravity. Finally, a fourth series represents the particular item in the main weight group. Thus the number 1111, according to this classification, represents the shell of the ship, *as designed*, which is part of the hull weight, and which is of considerable influence on the position of the centre of gravity. A specimen classification is given in this connection. Such a classification enables the comparison of different types to be directly carried out from the point of view of stability.—*W. Schmidt, Werft, Reederei, Hafen*, February 7, 1922, page 59; 5 pages; 5 ff.

Marine Boilers.

The development of the marine boiler is at a critical stage, and consequently the article attempts to deal with the problem of where it is best to fit the cylindrical and where the water-tube boiler. The general requirements of all boilers such as efficiency, security, compactness, lightness, low upkeep, &c., are carefully outlined, and the rapid adoption by the French Admiralty of water-tube boilers, instead of the older cylindrical type, is considered in the light of their possible application to merchant ships. The cylindrical boiler has undoubtedly attained its limit, further increase in size necessitating hardly practicable scantlings. Moreover, the ratio of boiler weight to grate surface (m^2) increases from about 8·7 for 180 lb. pressure to 12·5 at 215 lb. pressure, and even this ratio is only obtained at the expense of lower factor of safety. The upkeep charges may be small, but repair costs may be high and necessitate the laying up of the vessel. Due to the enormous quantity of water contained, the boiler is not sensitive to inattention on the part of the engine staff. While a good combustion may be obtained only a poor circulation of heat is produced, giving rise to considerable temperature stress which fatigues the structure. The cleaning of this type of boiler is comparatively difficult and in some parts impossible. The water-tube boiler originated in naval vessels due to the necessity to raise steam rapidly, and also to reduce weight and space as much as possible. The boiler is simple to construct and to repair, especially since repairs are necessarily restricted to small parts, and for larger units no reduction in safety need occur. The greater circulation of water due to the relatively smaller volume greatly increases the efficiency of this type, and tending as it does to equalise temperatures, also reduces temperature stresses and consequent fatigue. This type is much more sensitive to inattention of stoking than the cylindrical type and requires careful personal attention—a thing not always possible on merchant ships. Careful attention must also be given to the feed water, unless automatic regulators are fitted. Making a final comparison, the low attention necessary for the cylindrical boiler will enable it to be still profitably fitted in pure cargo vessels, but for high-class passenger vessels only water-tube boilers should be fitted. The well-known Belleville boiler has recently been improved. The ordinary type is described and the new double spiral tube type is dealt with at length. This type enables the rapidity of circulation to be greatly increased and even allows the usual economiser to be dispensed with. This type of boiler was fitted in 1913 to the French cruisers *Flandre* and *Languedoc*, and later in the 25-knot passenger vessel *Versailles*. In this latter two groups of four units having a total grate surface of 660 sq. ft. easily yielded a total horse-power of 16,000, and a 15 per cent. overload could easily have been produced. Various land applications have been made and the improved type has undoubtedly passed the experimental stage. It has the long experience of the Delaunay-Belleville firm behind it and should prove a valuable contribution to the economy of the mercantile fleets of the future.—*P. Lorain, Bull. Tech. du Bureau Veritas*, January, 1922, page 21; 3½ pages; 1 ff.

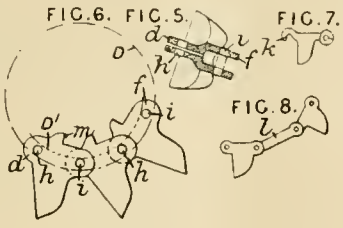
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 169,012. Turbines.

J. P. M. Malleville, 115, *Boulevard Exelmans, Paris. June* 16, 1920, *No.* 16331. [*Class* 110 (iii).]

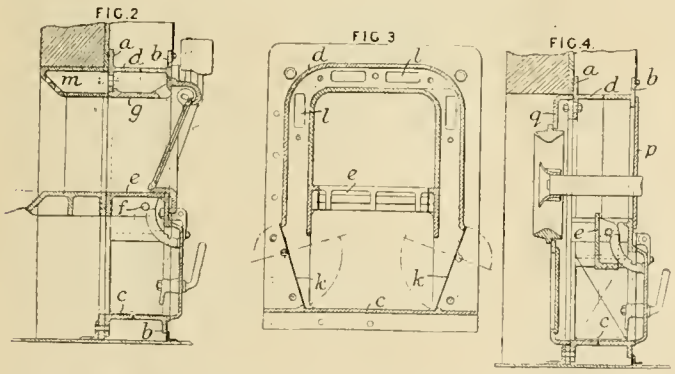
The buckets or blades are secured together in a chain-like manner and mounted around the periphery of a disk, drum, or polygonal member by means of pins or other driving members. Each bucket is formed with spaced lugs *d*, *f*, Figs. 5 and 6, through which pass pins *h*, *i* to connect them together and to a disk D. Alternatively, the pins may abut on the periphery of a disk D^1. Driving pins *m* may be provided on the surface of the disk D. The buckets may be interconnected by hooks *k*, Fig. 7, or by links *l*, Fig. 8. Several rows of buckets may be mounted on a disk or drum.



No. 169,037. Furnaces.

R. Baillie, 4, *Lloyd's Avenue, London.*—(*J. Reid*, 30, *Church Street, New York, U.S.A.*) *July* 2, 1920, *No.* 18134. [*Class* 51 (i).]

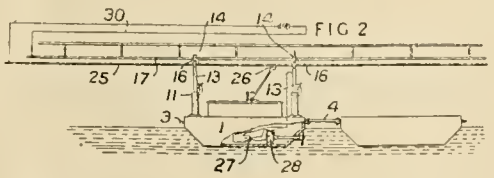
A furnace front for water-tube boilers adapted for coal or oil firing and having the usual front plate *a*, Figs. 2 and 4, and back plate *b* provided with projections which meet to form the ash-pit flare *c* and air casing *d* is provided below the level of the sill *e*, which may be removable or adapted to be tilted on the pivot *f*, as shown in Fig. 4, with lateral valves *k*, Fig. 3, for controlling the distribution of air to the ash-pit and air casing surrounding the firing opening. For coal firing, the sill *e* is held in its horizontal position by the lower part of the removable casing *g* forming the firing opening. Air passes through openings *l* in the air casings to air supply baffle-boxes *m*. Fig. 4 shows the firedoor replaced by a plate *p* carrying a burner, the casing *g* and baffle-boxes *m* being removed and a plate *q* carrying a burner opening being bolted to the plate *a*.



No. 169,105. Propelling Boats.

M. R. Loija, 8, *Brickdam, Georgetown, Demerara, British Guiana. September* 27, 1920, *No.* 27461. [*Class* 114.]

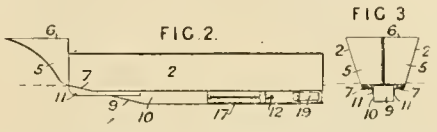
Electrically-propelled boats taking power from a trolley wire have adjustable guide members engaging guiding cables or rails. Standards 11 on the boat 1 carry rack bars 13 with bifurcated ends 14 carrying pulleys 16 which engage guide-cables 17. Pinions are used for raising the rack bars, which are retained by pawl mechanism; for lowering, the pawls are released and the bars fall by gravity. Current for the motor 28 is picked up by a trolley 26 from a wire 25 and returns by one of the standards to the return wire 30, a reversing switch 27 being inserted in the circuit. The boat has eyes 3 for taking coupling bars 4 when towing.

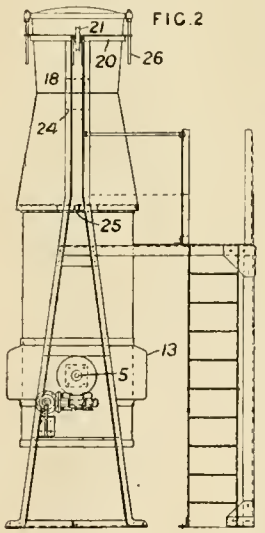


No. 169,390. Boat Hulls.

J. E. Langstaff, Brooklyn, New York, U.S.A. October 13, 1920, *No.* 29023. [*Class* 113 (ii).]

Hulls.—A power-driven boat hull has a bottom from which depends a well 10 having an upwardly and forwardly extending bottom 9, upwardly diverging side walls 2, and a forwardly and outwardly curved bow 5 which may have upwardly and outwardly diverging concave side walls. The bow may extend above the main hull 2 and carry a deck 6. Plates 11 arranged adjacent to the sides of the well 10 extend forwards on opposite sides of the inclined bottom 9 and form a recess or channel for the water. The bottom of the main hull is upwardly and forwardly inclined at 7, in the same plane as the bottom 9. Propellers 12 and a rudder 19 are disposed between a plate 17 extending from the bottom of the well 10 and the main hull bottom.





No. 171,491. Furnaces.

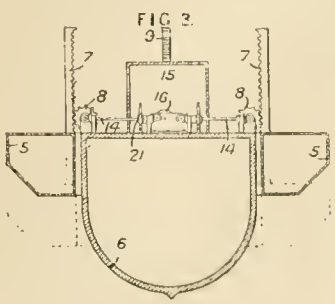
Wood, W. H., and Wood, D. H., 7, *Augusta Road, Moseley, Birmingham. August* 19, 1920, *No.* 24102. [*Class* 51 (ii).]

A small cupola is mounted in a framework on trunnions 5 affixed to an air belt 13, one trunnion being hollow for the introduction of the blast, and a spark arrester 18 is slidably mounted on the same framework so that it can be lifted when the cupola is to be tilted. The upper part 24 of the framework is formed of parallel vertical members constituting a guide for projections 25 on the spark arrester, to which are attached wire ropes running over pulleys 21 at the top of the framework. The upper part of the spark arrester is guided by pins 26 engaging holes in a ring 20 forming the top of the framework. The cupola is tilted by worm gearing. The blast fan is also mounted on the framework. A platform and ladder may be combined with the structure as shown. The cupola is charged through a door in the side of the spark arrester. The whole structure may be mounted on a wheeled base.

No. 171,625. Ships.

Dedik, Y., Box 61, *Boswell, Pennsylvania, U.S.A. December* 1, 1920, *No.* 33967. [*Class* 113 (i).]

In a ship protector of the kind comprising a float 5 encircling the ship 6 and capable of being raised or lowered, the float is provided with racks 7 gearing with pinions 8 driven by an engine carried by the vessel. An additional steadying rack 9 gearing with an idle pinion is fitted at each end of the float. The pinions 8 are bevel-geared to shafts 14 which are driven



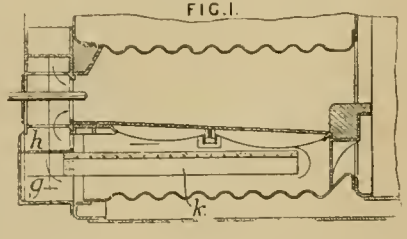
from a motor 16 in the cabin 15 through spur and bevel gearing. Each shaft 14 is fitted at the inboard end with a clutch 21 for throwing it out of gear with the motor, so as to allow the float to lower itself under the action of gravity.

No. 171,793. Furnaces.

Reid, J., 4, *Lloyd's Avenue, London. August* 25, 1920, *No.* 24686. [Class 51 (i).]

A steam boiler furnace adapted for burning coal or oil is provided with a hollow furnace front having a lower compartment *g* supplying air to the ash-pit, where it is heated by passing around a baffle-plate *k*, and along the underside of the grate which, for oil-firing, is covered with asbestos sheeting and brick tiles or the like, and a separate compartment *h* receiving the heated air from the ash-pit and delivering it to the burner. A tube or tubes may be used in place of the baffle-plate *k*.

FIG. 1.



No. 171,917. Determining Ships' Courses.

Carey, R. E., 147, *Dover Road, Folkestone. December* 29, 1920, *No.* 36365. [*Classes* 97 (ii) *and* 106 (i).]

Relates to an instrument for ascertaining the correct course of ships by taking at equal intervals three compass bearings of a distant object; the instrument may also be used by a stationary observer to determine the course of uniformly - moving vessels. The instrument upon which the bearings taken are set for calculating the course comprises a base *a* having a rotatable rim *b* divided like a compass card. An arrow-head A upon the base is set to the second compass bearing and the respective differences between this bearing and the other two are set by arms *w*, *x* pivoted upon a quadrant *r*, which is provided with a scale for setting the arms and is mounted upon guideways so as to be capable of sliding along the diameter of the base passing through the arrow A. A pivoted pointer *e*, *f* is set to indicate on the rim *b* the required course by sliding the quadrant *r* upon the base *a* until the arms *w*, *x* come into contact with a centrally - disposed vertical plate *k* mounted on the disk *g*, carrying the pointer *e*, *f*. An arrow-head B is used in the case of a stationary observer for setting the second bearing.

FIG. 1.

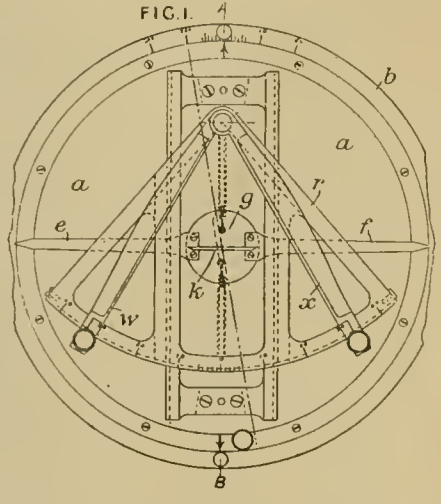


FIG. 2

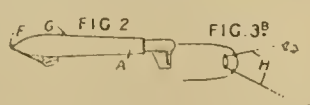
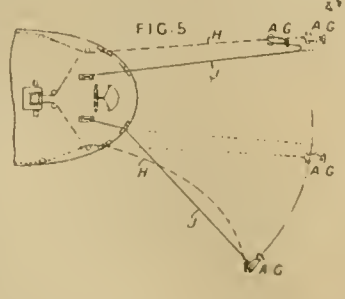


FIG. 3b

FIG. 5



No. 171,932. Steering Ships.

Law, C., 39, *Dean Road, Bo'ness, Linlithgow. August* 17, 1920, *Nos.* 4284 21 *and* 13476 21. [*Class* 114.]

Consists in using submersible towed bodies such as paravanes in pairs for emergency steering of ships, each towed body having either one or two towing wires. When one wire H, Fig. 3b, is used for each paravane, steering is effected by hauling in one wire on the port or starboard side and paying out the wire of the paravane on the other side. When two wires H, J, Fig. 5, are employed, they are attached to the points F, G, Fig. 2, of the paravane. The port and starboard wires J are of equal length, and are attached at fixed points to the ship, whereas the wires H are led inboard to the main steering chains, or to a winding medium, such as a winch, so as to be adjustable relatively for steering as shown. More than one pair of towed bodies may be employed.

No. 171,982. Turbines.

Taylor, H. B., c/o W. Cramp & Sons, Richmond Street, Philadelphia, U.S.A. November 1, 1921, *No.* 29048. *Convention date, November* 20, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

FIG. 6.

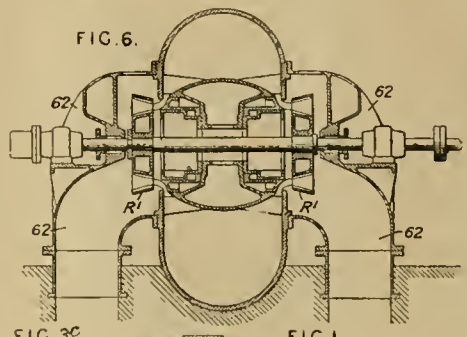


FIG. 3c

FIG. 1.

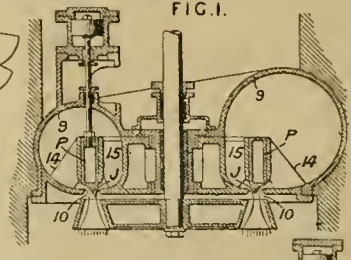
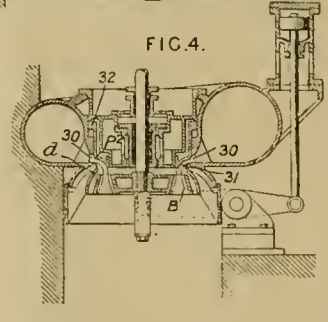


FIG. 4.



In a high-speed hydraulic impulse turbine, the jet of water supplied to the rotor buckets B is in the form of an unbroken ring J, the water flowing through a volute casing 9 having guide vanes 14, 15 and an annular discharge orifice 10 adapted to be throttled by a plunger P, which is actuated by the turbine governor through two or more fluid-pressure operated pistons. A plan view of the buckets B is shown in Fig. 3c. In a modification, Fig. 4, the plunger P2 controlling the annular orifice 30 has its lower end 31 curved to turn the jet axially on to the buckets B, and the fluid pressure for operating it acts on its upper part 32. A deflector *d* or the like may be provided so as to by-pass when raised the water flowing to the buckets B. Fig. 6 shows a duplex balanced arrangement on an horizontal shaft, the water discharging from the turbine runners R1, R1 into casings 62, each shaped as a double spiral.

OFFICIAL NOTICES.

THE Proprietors of Letters Patent No. 122,427 relating to PROPELLERS desire to dispose of their Patent, or to grant licences to interested parties on reasonable terms with a view to the adequate working of the Patent in this country. Enquiries to be addressed to Cruikshank & Fairweather, 65–66, Chancery Lane London, W.C.2.

THE Proprietors of the Patent No. 100,346, for Improvements in Submarine Boats, are desirous of entering into arrangements by way of licence and otherwise, on reasonable terms, for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to Haseltine, Lake & Co., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

THE Owners of British Patents No. 10,562, of 1913, for "Improvements in or relating to Devices for use in Controlling the Bulkhead Doors on Ships or other Doors," and No. 18,677, of 1913, for "Improvements in or relating to Valve Apparatus for Use in Opening and Closing Bulkhead and other Doors," are desirous of negotiating with interested parties, either for the sale of the Patents or for the granting of licences thereunder on reasonable terms. Communications please address to Dicker & Pollak, 20-23, Holborn, London, E.C.1.

Foreign Orders for German Yards.—The Deutsche Werft, Hamburg, announces important orders received for vessels to be built to foreign account. Three large motor ships are to be built for the firm of Wilh. Wilhelmsen, Christiania. Two of these vessels will be of 8,000 tons d.w. capacity and the third of 8,800 tons d.w. The vessels will be fitted with Diesel engines on two shafts, under licence from Burmeister & Wain, and will be used for cargo and meat transport on regular lines to La Plata and Australia.

The Marine Engineer
AND NAVAL ARCHITECT.

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Mr. Alex. Spencer has been appointed Vice-Chairman of the Metropolitan-Vickers Electrical Company Limited in succession to the late Sir Francis Barker.

Mr. R. S. Johnson has been appointed Managing Director of Cammell Laird & Co.'s Birkenhead works in succession to the late Sir George Carter, K.B.E. Mr. Johnson, who went to Birkenhead in May, 1920, was formerly a Managing Director of Workman, Clark & Co. Limited, Belfast.

The death occurred recently, at Southampton, of Captain F. J. Moseley, Marine Superintendent of the Union-Castle Mail Steamship Company Limited. He joined the company as fourth officer 35 years ago and attained the rank of Commander in 1893, and has commanded most of the large vessels of the line.

Commander E. C. Shankland, R.N.R., who has been appointed Chief Harbour Master on the River and Port of London, was for the past seven years assistant water bailiff and marine surveyor to the Mersey Docks and Harbour Board. Commander Shankland has specialised in meteorology and hydrographic work. He served in the Admiralty Hydrographic Service in Newfoundland, Bermuda and the West Indies, and afterwards was engaged on the survey of the Solent from 1911 to 1914. He is an extra master, a Younger Brother of Trinity House and a Fellow of the Royal Meteorological Society.

The death has occurred at Ilford of Captain Peter Harris, who had been in the service of the P. & O. Company for more than 50 years, having joined as fourth officer on the *Poona* in 1865. During the last 20 years of his service he acted as Dock Superintendent for the company at Tilbury. On his retirement in October, 1916, at a farewell dinner which was accorded him, Lord Inchcape specially referred to the services rendered by Captain Harris in his long association with the company.

Mr. D. B. Gebbie, who has resigned his position as Manager of H. & C. Grayson's Shipbuilding and Ship-repairing Works, Garston, is commencing a private practice as a consulting naval architect, with offices in Liverpool and Glasgow. Mr. Gebbie went to the Liverpool firm four and a-half years ago with the primary object of developing the Garston works. The extent of his success is patent to anyone intimate with these yards, which are now well equipped with plant, shops and berths for the construction of all classes of shipbuilding and for ship-repairing. During his management Grayson's built many classes of vessels, for the design and construction of which he was responsible, and have carried out a large amount of successful repair work, the whole of which reflects great credit on Mr. Gebbie, and which experience will undoubtedly prove invaluable to him in his new sphere. It is pleasing to note that he has not entirely severed his connection with his old firm, but is to be retained by them in a consultative capacity. It is anticipated that he will devote special attention to developing the system of ship construction known as the "G.A." system, which Mr. Gebbie and Professor T. B. Abell, M.Eng., invented.

Mr. John George Kinghorn, Senior Partner of the Metallic Valve Company, Liverpool, whose death has occurred at Prenton Hill, Birkenhead, was in his 73rd year, and was the eldest son of the late David Kinghorn, of Glasgow, for many years Managing Director of the London & Glasgow Shipbuilding & Engineering Company Limited. He came from a long line of shipbuilders on the Clyde, being a descendant of Robert Napier, one of the pioneers of steam-propelled vessels. The deceased received his early education at the Glasgow High School, proceeding thence to the Glasgow University, where he studied under Professor Rankine. He served his apprenticeship with Aitken & Mansal, and with the London & Glasgow Shipbuilding & Engineering Company Limited. During his seagoing career he sailed in many vessels famous in their day, and in 1870 was guarantee engineer on the *Queen of the Thames*, the first steam-driven vessel to make the voyage to Australia, and was aboard that vessel when she was wrecked in Strews Bay, South Africa, in 1871, while on her homeward voyage. Mr. Kinghorn remained with the London and Glasgow Shipbuilding & Engineering Company Limited for some time, during which period he had control of the construction of many famous vessels. In 1874 he joined the surveying staff of Lloyd's Register as a combined engine and ship surveyor at Liverpool, retiring in 1884 to practise on his own account as a consulting engineer and naval architect, and also to found the firms of Kinghorn Brothers and the Metallic Valve Company for the manufacture of Kinghorn metallic valves under the various patents which he took out from time to time. The Kinghorn patent valves are now a household word in the engineering profession.

EDITORIAL.

OIL FUEL IN MARINE BOILERS.

THE recent conversion of the *Mauretania* from coal-burning to oil-burning, which we have separately dealt with in this issue, raises again the question of the relative merits of the two methods of steam production. Since the conversion of the *Aquitania* and the *Olympic* to oil-burning about two years ago much valuable experience has been gained in the economical use of oil fuel. With the subsequent conversion of the *Mauretania*, the *Berengaria* and the *Majestic*, the first of which has resumed service and the last two of which will shortly take up their station at Southampton, there would appear to be a strong case in favour of oil for the North Atlantic passenger service. Having regard to the comparatively recent advent of oil as a steam producer, so rapid a stride to a commanding position, against such an entrenched rival as coal, must be regarded as closely approaching a demonstration of superior efficiency. Lloyd's Register returns for the year ending June 30, 1921, gave a remarkable indication of the tendency in this connection, since it is shown that 58 per cent. of the total deep sea tonnage constructed in the British Isles during that year was oil-burning, and this percentage takes no account of vessels converted from coal to oil in the same period. In view of the foregoing, it is the more noteworthy that the ex-German White Star liner *Homeric*, which recently took up service between Southampton and New York, still functions on coal.

The question of continuity of supply is one which more than any other has militated against the adoption of oil as a fuel on many of the steamship routes of the world, and the importance of studied economy in the use of mineral oil has been urged by many. Professor Armstrong, writing to *The Times* in June, 1920, deplored the fact that the furnaces of the *Aquitania* and *Olympic* had been converted to use oil instead of coal, and at that time he urged economy in the use of oil for steam-raising in view of the future requirements of internal-combustion engines. While there may be virtue in this argument, it is nevertheless open to question whether the consumption of 7,000 tons of oil or the equivalent 14,000 tons of coal in the *Aquitania* represents the greater loss to posterity. The enormous saving in labour rendered possible by the adoption of oil, and the fact that to-day the Diesel engine, even in its admittedly improved state, has yet to travel far before it can be adopted in a vessel of the *Aquitania's* calibre, would seem to offer ample justification for the adoption of oil as a fuel in vessels of this class.

Coaling a ship is an unpleasant business for all who are anywhere in its proximity. It is also, both directly and indirectly, a source of expense to owners through the percolation of coal dust into every nook and cranny which is not specially sealed against its ingress. Portholes must be kept closed, state rooms battened down, and those who are on the ship live a life comparable only with that of a prisoner undergoing sentence. All work of a decorative nature must be stopped, and it is impossible to undertake any external painting. Under the new *régime*, while the passengers and their baggage are being disembarked, an oil barge draws up on the offside of the ship and delivers fuel amounting to 6,000 or 7,000 tons within a few hours, and in some cases before the last of the passengers has left the ship. Such features presumably do not strike the transatlantic passenger with such force as they would in the case of long-distance voyages, say to Australia, where frequent coalings are necessary, but they manifest themselves in the owner's annual bill for upkeep, they render the ship more immune from delays through bunkering quarrels, and generally make for more harmonious conditions and a better-natured ship's complement on sailing day.

The question of cost cannot be dissociated from any discussion on the relative merits of coal and oil as a fuel. As the costs of coal and oil are subject to periodical fluctuation it is a matter of difficulty accurately to define any standard ratio; but such are the advantages of oil over coal that it would be necessary for the price of the former to rise to a point two and a-half to three times that of the latter before these advantages would be neutralised. As a fair average present-day comparison the price of coal may be said to be about half that of oil. As an offset to this two-to-one initial cost factor in favour of coal some of the advantages of oil may be stated. Primarily, the steam-raising power of oil is such that approximately two tons will generate the same quantity of steam as three tons of coal. As a coal-burner the daily fuel consumption of the *Olympic* was about 900 tons, which has been reduced under oil-burning conditions to 600 tons. On one port-to-port transatlantic run this represents a saving of roughly 2,000 tons, or 4,000 tons on the round voyage. Furthermore, as a coal-burner the *Olympic* carried 246 firemen working under unpleasant conditions, but to-day 60 men attend the same number of furnaces under healthy and comfortable conditions. By the more compact stowage and the smaller weight of oil to be carried, space is released for purposes producing, or directly tributary to, revenue.

Having regard to the extensive adoption of oil as a steam-raiser and also in the internal-combustion engine, and to the fact that as yet there has been found no reliable substitute for mineral oil as a lubricant, the opinion of experts that the world's supply will be exhausted within from thirty to fifty years is disquieting. Provided the supply of oil were assured and that the relative costs of coal and oil could be made more nearly equal, it may safely be said that, in merchant tonnage, coal will never regain its quondam supremacy. With these facts before him the shipowner cannot fail to appreciate the need for economy in operation.

EFFECT OF DRAUGHT ON PERFORMANCE.

TO anyone conversant with model experimental work the multiplicity of difficulties met with need not be elaborated, and the inherent weakness of model work, unless checked and supplemented by full-scale practical experiments, frequently provides a real source of discouragement. In any analysis of the performance of ships many factors arise which are extremely variable in value, and an exact measure of the variations of such values is very often extremely difficult to obtain. The trial performances of a certain group of vessels, alike in form and in dimensions and with the same size and shape of propellers, differed by as much as 15 per cent. Such vessels defy reasonable analysis, and broad conclusions only can be drawn from the available data, and the particular features which brought about the differences in results remain, practically, a matter of conjecture.

It is probable that one of the chief causes of the observed inequality in results is the uncertainty as to the mechanical efficiency of marine engines. The group of vessels mentioned above were fitted with reciprocating machinery, and although most engineers would at once suggest that an efficiency of around 90 per cent. could be assumed for such, it soon becomes evident to any analyst of trial results that an efficiency much smaller must be accepted if any reasonable analysis is to be arrived at. The remarkable case of a certain paddle steamer may be cited in this connection. This vessel went on trial immediately after completion, and a result was obtained which was indifferently good. Some time afterwards rather good reports were forthcoming about the turn of speed which she was showing. It was thought desirable to run further measured mile trials, and exactly a year after she first went on the mile she gave a performance which indicated over a knot increase in speed, with the same expenditure of power as on the first occasion. The form, of course was the same, the vessel's skin was freshly painted in both cases, and the only possible

reason for the great improvement observed was that the machinery was running sweeter. It was found that no less than 30 per cent. of the power developed in the first trial had been absorbed in the friction of the moving parts.

The above results with the same ship are illustrative of what frequently occurs, namely, that the voyage records of a vessel may show widely divergent results. From some published logs of a certain vessel it had been found that the propulsive efficiency varied from around 30 per cent. to well over 50 per cent. In her case the weather conditions had much to do with the variations observed. But again, it has been observed that the conditions of draught had an enormous effect on the values of the Admiralty constant obtained on trial and on service.

Recently a full, slow vessel went on trial and gave a very low figure of performance as measured by the Admiralty constant. The low constant led to a little investigation into the cause, and it was found that the very light draught at which she was running accounted for the apparently poor result. It is well known that in full ships diminution in resistance in pounds per ton of displacement is obtained with increase in draught. In this type of ship frictional resistance forms the major part of the total, and at a light draught the amount of shell surface in proportion to the displacement of the ship is very much greater than is the proportion when the load draught is reached. Added to this effect of draught on resistance, the ineffectiveness of a propeller when only partly submerged must be considered. It has been demonstrated by experiment that the thrusting qualities of a screw are seriously diminished when the tips are only awash, and become more affected as they are emerged. Not only so, but the torque required to produce this diminished thrust does not diminish in a corresponding degree. The efficiency thus becomes seriously affected. It is possible that to the aid of this low propeller efficiency there comes, if we may so put it, a high hull efficiency value, or, in other words, a great wake gain, for although the Admiralty constant is low the propulsive efficiency may be fairly high. This indicates, therefore, that the cause of a low constant being obtained is the high resistance through the great amount of surface for the displacement condition. Occasionally the question of this relationship of surface and displacement is thoughtfully considered, and the form which approximates to that of least surface for a given displacement is aspired to.

Whilst shallow draughts have thus an evil effect on the performance of slow full ships, it has been found that quite the opposite effect is given to fast vessels of the destroyer type. In this class the wave-making portion of the resistance greatly exceeds the frictional, and proportion and ratio of length to displacement practically dominate the results. Experiments have shown also that the nearer the form of a very fast vessel approaches the idea of a skimming form, so the resistance becomes diminished. It is even of advantage to increase the fullness and reduce the draught in certain cases, although the common idea is that very fine coefficients are required if very high speeds are to be obtained. The results of experimental investigations in this direction are reflected in the much fuller forms of torpedo boat destroyers than were formerly adopted. A few years ago a fullness of around 0·4 block coefficient was commonly adopted in this type of ship, but to-day a fullness of 0·55 is usual. Some experts in destroyer construction are well aware of the importance of diminution in draught if the maximum of speed is to be obtained, for every reduction in weight brings about a decrease in the power required for a certain speed greater than that indicated by a mere consideration of weight.

The foregoing remarks will illustrate the necessity of thorough investigation into the features which should dominate the forms of all ships. These must be considered in the light of the particular conditions to be fulfilled, and experimental work will afford direct guidance as to how the best can be attained.

STANDARDISATION AND ITS INFLUENCE ON TRADE.

IN everyday life we are each subconsciously influenced on the moral and social side by standards of conduct and standards of living—the entire fabric of citizenship is hemmed by such standards. With the application of standardisation to industry, however, we are more directly concerned, and under the stress of war we, as a nation, had perforce to revise established practices and ideas, and endeavour, by a process of co-ordination, to produce standardised requisites of war which should, with the minimum of duplication or overlapping, best serve the common good. In a paper on "Standardisation—its Fundamental Importance to the Prosperity of our Trade," read by Mr. C. le Maistre, C.B.E., before the North-East Coast Institution of Engineers and Shipbuilders on March 24, the author reviewed the progress which had been made by the British Engineering Standards Association, of which body he is Secretary.

Mr. le Maistre deals in a general way with the history of the movement and its principles; he discusses the importance and the direct bearing which research plays in the work of the Association, and he emphasises the need for increased vigilance abroad and—what would almost seem, *per se*, a contradiction—international co-operation. Standardisation in its broadest aspect may be said to imply the introduction, through collective effort, of economical methods of manufacture with a view to unifying the needs of industry and thus bringing about the greatest amount of good for the greatest number. Although the principle of standardisation has been fairly generally accepted by industry there are still those who believe that, in effect, it retards invention and progress, and that the arbitrary adoption of a standard shuts out the possibility of modification or change whereby new and superior methods which might, in the normal course, benefit production, are lost. The author points out that if practised on right lines this objection does not arise in industrial standardisation.

The community of interest of the buyer and the manufacturer is the fundamental idea underlying the work. Standardisation ensures that the buyer knows exactly what he can purchase, and that his exact requirements are met in return for his money. Furthermore, it simplifies the work of the manufacturer, accelerates output, reduces the cost of production and eliminates the possibility of mistakes being made. In the first place, proposals are submitted by the manufacturer, and constructive criticism is the work of scientific and technical experts. That may be taken to be the general rule, but in isolated cases, and rightly so, the converse may be the case. The first essential in the progress of standardisation is to secure the confidence of industry, and to this end standards must have, as far as may be possible, some degree of permanency. At no time should changes be made merely for the sake of change, but such changes should be made only when the highest consensus of opinion shows that they are distinctly in the direction of improvements. If this guiding principle is given effect the confidence of industry will be secured and, instead of stultification and fossilisation, improvement and progress will result.

At a time when British industry is passing through admittedly lean times anything tending to expedite production, and at the same time reduce first costs, will be doubly welcome. We feel that to a very appreciable extent standardisation serves this dual function, and in the excellent work already accomplished by the British Engineering Standards Association we have a shining example of what can be done in this direction. Foreign competition is, and is increasingly likely to be, of such intensity that we as a nation cannot afford to deny recognition of this or any other factor likely to make for facility of production.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Lektrik Lighting Connections. With introductory and explanatory notes by Gus. C. Lundberg, M.I.E.E., and the late W. Perren Maycock, M.I.E.E. Seventh edition. 261 diagrams and illustrations. 4 in. × $6\frac{3}{4}$ in. × $\frac{3}{16}$ in. Price 1s. net.

In the setting out of the electric light circuits on board ship there are many situations where the usefulness of the circuit could be considerably improved by the utilisation of switching arrangements other than that given by the simple single-way switch. This little booklet sets forth with diagrams and explanations the different arrangements that can be made, many of which should prove of considerable value. The book can be recommended to all who are anxious to learn how the usefulness and efficiency of the electric light can be increased.

"Notes and Examples on the Theory of Heat and Heat Engines." By John Case, M.A. Cambridge: W. Heffer & Sons Limited. $5\frac{1}{2}$ in. × $8\frac{3}{4}$ in. × $\frac{5}{8}$ in. 136 + 6 pp. Price 7s. 6d. net.

The first edition of this book appeared in 1913 under the title "A Synopsis of the Elementary Theory of Heat and Heat Engines," and in this, the second edition, the author has endeavoured, by the addition of a large number of clearly worked examples, greatly to increase the value of the book. Primarily, as Mr. Case has pointed out in the preface, this second edition lays no claim to be regarded as an exhaustive treatise on the subject, but is rather to be considered as a companion to lectures.

An excellent arrangement whereby the more important formulæ are printed in bold type has been adopted throughout, and to the student undertaking a course of rapid revision for examinations this book will, we think, make a strong appeal. For the marine engineer preparing for the Board of Trade examinations, with their ever-rising standards, many of the examples worked out on such practical applications of thermodynamics as air compressors, refrigerators, turbines, Diesel engines, &c., will be found to be very helpful. The book as it stands is well and clearly written, but may be considered from a practical standpoint to err on the side of brevity. The practical value of the sections dealing with turbines and internal-combustion engines might be enhanced by the inclusion of rather more explanatory text, and, in the case of the latter section, by the addition of more examples.

Machinery and Pipe Arrangements on Shipboard. By C. C. Pounder. London: Emmott & Co. Limited, 20, Bedford Street, W.C.2. $5\frac{1}{2}$ in. × $8\frac{1}{2}$ in. × $1\frac{1}{4}$ in. 440 + vii pages. Price 17s. 6d.

In his treatment of a subject which is manifestly complex and which embraces a sphere extending far beyond that indicated by the title, the author reveals a remarkably sound grasp of practical detail. Unlike the designer of machine details which involve considerations generally in themselves complete, the draughtsman engaged on arrangement work cannot carry through to completion any specific pipe range, say, without regard to other equally important and interdependent pipe systems. Primarily the subject is approached from the viewpoint of the designer, and to the junior draughtsman or to the student a close study of the text will bring much that is useful in solving problems of design. The scope of the work, however, is wider than this. The considerations affecting both the ship and the engine sides of the work have been treated in a very able manner, and with its wealth of practical illustrations the book as it stands is worthy the attention of the draughtsman responsible for machinery lay-out, the erector whose duty it is to give practical interpretation to the design, and the marine engineer whose function it is to operate the plant. This is a work of real merit, and should find a large sphere of usefulness.

The Marine Oil Engine Handbook. Sixth edition. London: Temple Press Limited, 7-15, Rosebery Avenue, E.C.1. 174 pages and numerous illustrations. $5\frac{3}{8}$ in. × $8\frac{1}{8}$ in. × $\frac{5}{8}$ in. Price 3s. 6d. net.

This little book has been written as a work of instruction for all who have to do with marine motors of small and moderate power, and it admirably serves its purpose. The different types of petrol, paraffin and semi-Diesel engines are described and illustrated after a number of preliminary chapters have been given explaining the action of the engine and its various details. The text, which is in simple, non-technical language, is illustrated by a number of diagrams and section drawings as well as by photographs of different engines, so that the explanations can be readily understood even by the non-technical reader. This book should be of great value to the man who has to do with any form of small motor vessel, whether for pleasure or for profit.

TRADE PUBLICATIONS.

Lubricating Oil.—The Vacuum Oil Company, whose London address is Caxton House, Westminster, S.W., have issued an interesting illustrated booklet on their various brands of "Gargoyle" oils and greases, with a list of ports where these lubricants can be obtained.

P. Smit Junr's Shipbuilding and Engineering Works.—The name "P. Smit" has been well known in the Dutch shipping world for a very long time, having been established at Slikkerveer in 1871 for building wooden sailing ships. The firm have now published a fine book giving illustrations of their workshops and of vessels which they have constructed, and repaired, for which class of work the yards are particularly well equipped.

Small Steel Craft.—J. S. Watson (Gainsborough) Limited, Gainsborough, builders of all types of steel river and port craft, have issued an illustrated booklet showing some of the vessels which they have constructed. Some of these craft were erected in the yard, then transported, and finally riveted up at their destinations, and consist of tugs, fishing vessels, lighters, barges, lightships, &c. The greater strength and durability of steel vessels has practically ousted wooden construction of this class. Messrs. Watson build craft up to 250 ft. in length, and have built over a thousand of this class of vessel.

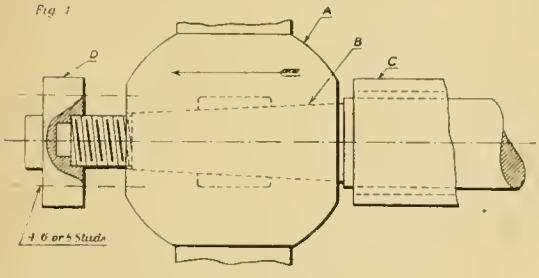
Burmeister & Wain.—To commemorate its transference into a limited company, 50 years ago, Burmeister & Wain, engineers and shipbuilders, Copenhagen, Denmark, have issued a handsome book giving the history of the firm, and particulars of its productions since 1872, special attention being paid to their Diesel engines. The volume is profusely illustrated, views being given of the management, the works, and of vessels either built or engined by the company, the whole forming a very interesting book which is worthy of bearing the name of

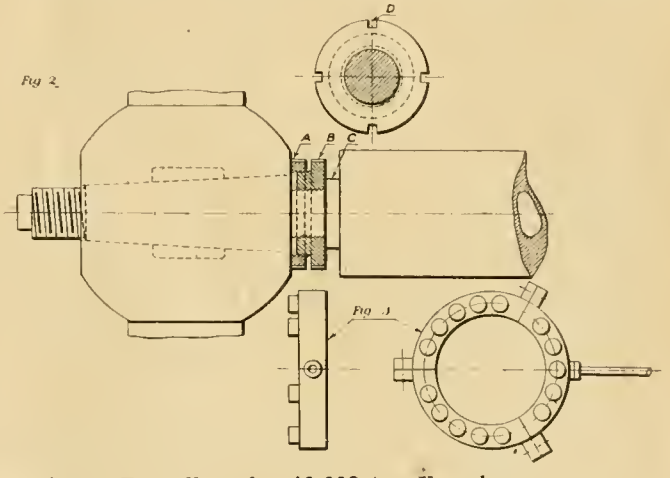
(*Continued at foot of opposite page.*)

ECONOMICS OF DISMANTLING.

Drawing a Propeller on a 10,000-ton Vessel.

Fig. 1 shows a convenient method of drawing a propeller from the tail-end shaft. A is the propeller boss, B is the cone of the shaft, and C is the ship's stern tube. D is a cap, a tool which should be a part of the ship's equipment and kept in the engineer's store ready for use. If not provided by the builders, such should be kept in various sizes by dock engineers. The sketch shows that the nuts, as well as the protecting cap for the nuts, have been removed. The cap is placed on the end of the shaft as shown, and existing stud holes (or fresh ones made) being fitted with suitable rough studs and nuts, it is only necessary to set tight on these studs—four, six or eight in number—when the propeller will come off without sound or danger. In cases where the propeller has been too obstinate even for this method, the most effective way is





Figs. 1-3.—Showing Proposed Methods of Drawing a Propeller of a 10,000-ton Vessel.

to heat all the studs in turn with an acetylene torch, set up the nuts tight and depend on contraction while cooling off, to provide the pulling strain. One valuable feature of this plan of removing a propeller is that no damage can accrue to the stern tube or its bush, neither is there any fear of the multi-collar thrust bearing nor the webs of the crankshaft being upset. There is always that danger when "wedging-off" from the stern tube.

In Fig. 2 an alternative method is shown which consists of a differential nut, which may be used either as a plain or a differential nut. This method must be incorporated in the original design of the shaft and propeller and provides an effective means of removing a tight propeller without putting any pressure whatever on the stern tube or bush.

A thread is provided on the propeller shaft, and this thread may take the Whitworth form and have a pitch of three threads per inch. The nut B engages this thread on the shaft, and the nut A, superimposed on B, is screwed four threads to the inch. These nuts should be, especially the threaded portions, of non-corrosive material—stainless steel, manganese or phosphor bronze. The nut B may be combined with the auxiliary nut A at will, by means of keys D driven into slots provided; while if it is desired to acquire greater power at the cost of speed, the nut A must be held from turning while the main nut B is turned by means of a heavy spanner and chain tackle. This spanner would engage in the slots provided.

It will be seen that when the two nuts are engaged by the keys D and turned together, one turn will force the propeller off $\frac{1}{3}$ in. If, however, the auxiliary nut A is firmly held from turning when the main nut is turned, the main nut screwing into the auxiliary nut one turn, the auxiliary nut will be drawn back $\frac{1}{4}$ in. So if the main nut advances $\frac{1}{3}$ in. and the auxiliary nut is drawn back $\frac{1}{4}$ in., we have the useful effect of the differential nut, and the propeller is pushed off a net distance of $(\frac{1}{3} - \frac{1}{4})$ in. $= \frac{1}{12}$ in. This, it is seen, requires only a quarter of the power necessary if both nuts are rotated in unison.

In Fig. 3 a suggestion has been put forward by the author. Briefly, this consists of a hydraulic ram, with the circumference divided up into three equal sections, similar to Messrs. Young's propeller remover, but with a number of small rams to each section instead of Messrs. Young's segmental form. It is suggested that a number of simple circular rams, with common commercial "hat" or Brahmah leathers, are less expensive to keep in repair and more within the resources of a docks shop for that purpose. This method has been successfully applied for many years to the removal of large spur wheels from heavy factory rolls.

Trade Publications– (*continued from page* 134).

this company of which much has been heard since the increase of moter ship construction.

William Beardmore & Co. Limited.—The latest catalogue issued by Wm. Beardmore & Co. Limited's publicity department, of 183, West George Street, Glasgow, is devoted to the Beardmore-Tosi Diesel engine, which was described in our pages last month. A general specification of this engine is given together with illustrations of the various parts and approximate overall dimensions of the four standard types of engine. In addition, information is given with regard to the number of auxiliaries nominally carried in a single or twin-screw ship, and interesting figures relating to the comparison of running costs of Diesel ships with steam ships of 1,000 b.h.p. and 2,400 b.h.p. The publication is very finely illustrated, and is sure to be very useful to all interested in the question of ship propulsion and Diesel engines.

CONVERSION OF THE "MAURETANIA" TO OIL-FUEL BURNING.

World's Fastest Liner resumes Service as an Oil-Burner after reconditioning by Swan, Hunter & Wigham Richardson Limited—Some Special Features of the Wallsend-Howden Installation.

That the conversion of the *Aquitania* from coal to oil-burning has been attended by conspicuously successful results may be gathered from the decision of the Cunard Steamship Company some months ago to carry out a similar conversion on the *Mauretania* and the *Berengaria*. The work of converting the *Mauretania* was entrusted to Swan, Hunter & Wigham Richardson Limited, Newcastle-on-Tyne, and on Saturday, March 11, she left the Tyne to take up her station at Southampton preparatory to resuming service on the Southampton-New York run on March 25. A large party of guests made the run round from the Tyne to Southampton, and the passage was completed under easy steaming conditions, the new installation giving satisfactory results.

The vessel is fitted with 23 double-ended and two single-ended boilers, and the internal coal-burning furnace fittings were entirely removed. Except in a few cases the existing furnace fronts have been utilised, and these fronts have been adapted to take the fittings of the Wallsend-Howden low-pressure system of oil-fuel burning. This system works under Howden's forced draught as originally fitted in the ship, and the total number of individual burners in the new installation is 192.

We reproduce on page 138 a sectional view of the burner and carrier showing the method of attachment. A special feature of this burner is the ease with which it can be removed, and the operation of removing and replacing with a clean burner may be effected in a matter of a few seconds without disconnecting any pipe unions.

Tank Storage and Piping Arrangements.

A fuel capacity of 5,350 tons has been provided, and this can subsequently be increased should it be found necessary. Unlike the *Aquitania*, the *Mauretania* carries no fuel in her double-bottom tanks. To provide this capacity the wing watertight compartments, previously used as coal bunkers and extending for the full length of the boiler rooms, have been converted to oil-fuel tanks. In making this conversion an enormous amount of work was involved. Bunker doors, ash ejectors, and ash ejector pipes were entirely removed, and a considerable weight of new steel was worked into the tanks.

The subdivision has been so arranged that 15 storage tanks are provided on each side of the ship. In each boiler room two tanks are used as settling tanks, and a transfer pump installed in each compartment draws fuel from the storage tanks, and supplies the settling tanks. Heating coils are provided in the settling tanks and also in the storage tanks. In the former these coils provide a heating surface of 2½ sq. ft. per ton of oil, and in the latter the heating surface is only about 1½ sq. ft. per ton of fuel. The higher heating surface provided in the settling tanks is to assist in the separation of water from the oil. As a general rule, it may be said that the fuel is taken aboard at a temperature of 100° to 110° Fahr., and as the temperature of the boiler-room wings in the vicinity of the storage tanks is very little less than 100 deg., it is anticipated that, under normal conditions of working, there will be no necessity to use the storage tank heating coils.

The after storage tank on each side is used as an overflow reservoir, and a common overflow pipe, one on each side, is so arranged that the overflow from any individual tank is led to the after reservoir. From the plate drawings which we publish in this issue the general arrangement of the pipes and pumps will be readily followed. The scheme of suction and filling pipes adopted is such as to ensure that the failure of any compartment will not prejudice the working of the system as a whole. For the entire length of the boiler rooms on each side of the ship a large suction and filling main is arranged. These mains are cross-connected in each boiler room and shut-off valves are provided at the watertight bulkheads. A filling and suction connection is taken from these mains to each of the storage and settling tanks, and with this arrangement each compartment may be operated independently. From each storage tank two air pipes are taken, and these are led to a common junction piece, as shown in the photograph on page 139. The lower section of this junction piece connects to the common overflow main, and from the top of the junction piece, which is incidentally the highest point in the air and overflow system, an air pipe is taken and led up the funnel hatch to a point about 25 ft. above the casing top in the open air. If, through an error in judgment, or from any cause whatsoever, the after overflow reservoir should become filled and should be called upon to stand excess pressure, a relief overflow connection is led from the tank through a non-return and storm valve over the ship's side above the waterline. Such a condition is never likely to arise, but this provision is made so that there should be no possibility of structural damage being sustained by the tank.

Filling Stations—"Bellows" Expansion Pieces—Tank Gauges.

Four filling stations are provided—two on each side—and situated above the main deck. The piping is so arranged that the vessel can fuel from either side or from both sides, and the ship can be fuelled to capacity in a period of eight hours. The two forward filling stations supply their own side of the ship only, but the two after stations are arranged so that each may supply the port or starboard tanks, or both. A relief valve is provided in each filling main so that in the event of excessive pressure being set up the relief valve by-passes the fuel to the overflow pipe. Large capacity filters are provided at all four stations, as shown in the photograph. To facilitate bunkering at New York the ship supplies the barge pumps with steam, and for this purpose a steam main is led to the filling station. This main is a permanent fitting, and is provided with a stop valve at the filling station so that the attendant may control the rate of supply of fuel without reference to the barge.

A special feature of this installation is the Wallsend "bellows" expansion piece, details of which are shown on the accompanying plate drawing. This expansion piece has been designed to eliminate cumbersome bends, and is fitted at various points in the system as denoted by "E" in the drawing. The fitting consists of two large flange or diaphragm pieces double riveted and welded at their outer joint and carrying the standard 8 or 6-in. flanges on their inner body. Exhaustive pressure and temperature tests were carried out on these expansion pieces to establish their suitability for work of this nature, and the results were in every respect satisfactory. It is believed that this is the first instance of this type of expansion piece having been fitted for this purpose, and although the temperature range in the main pipe lines will only vary within small limits, these expansion pieces perform an important function, and their performance on service will be watched with interest.

At a point near the top of each tank very heavy glass level gauges are fitted to facilitate the filling of these tanks. The

Board of Trade require that these gauge glasses shall be isolated by a valve which is held on its seat by a spring, and is only operated when it is desired to obtain a reading of the oil level. At all other times this valve remains automatically closed and the gauge glass is kept free from oil. A complete system of Pneumercator gauges is also fitted, by means of which the level of the fuel in any tank may be ascertained. In the photograph showing No. 2 stokehold forward, single-end sections, one of these gauges is shown (on page 140), and the equilibrating hand-pump will be readily seen.

Fuel Pumping and Heating Arrangements.

In each compartment a transfer pump is provided which draws from the storage tanks and discharges to the settling tanks. The pressure pumps, which are of the Weir type, are embodied in the self-contained pumping and heating unit which is a feature of the Wallsend-Howden system. This combined unit is very compact, and can be completely assembled in the shop, thereby simplifying the work of erection on board and eliminating involved pipe arrangements. Three of these units are installed in each of the four boiler rooms, and are of such capacity that under normal working conditions two of the units will meet the requirements, and the third will be maintained in reserve. In the ordinary course of affairs the pressure pumps take their fuel from the settling tanks, but additional connections are provided so that these pumps may draw from the storage tanks direct. It is highly improbable that during periodical overhaul or survey, or at any other time, the vessel will be totally without steam, but should this arise a compact motor-driven emergency starting set has been installed in No. 4 stokehold centre section, as shown on page 139. The necessary current may be obtained from the emergency Diesel generating set on board, or alternatively, may be taken from shore supply if available, and the boilers may be started up from cold by this means.

Combustion and its Control.

Considerable progress has been made within the last few years in arriving at more economical methods of burning liquid fuel, and a comparison between the earlier wasteful method of fuel atomising through the medium of a steam jet, and the method adopted in this installation, will indicate in some degree the extent of that progress. In its path from the storage tanks, through heaters, filters, pumps and furnaces until it reaches the atmosphere, the fuel and its products are subjected to constant observation by means of instruments and apparatus of the highest precision and proved utility. The Howden system of forced draught, as used in the vessel when coal-burning, has been retained with only minor modifications affecting the furnace distribution. Where a common air-duct supplies draught to a battery of several furnaces care has been taken, by adjusting the branch openings, to ensure that air of uniform volume and velocity is admitted to each furnace, and this condition, once established, has been fixed. With the Wallsend-Howden system the best conditions of combustion are obtained with a pressure of 80 lb./in.^{2} at the burners and with the fuel at a temperature of approximately 250° Fahr. These conditions of temperature and pressure must, of course, be considered in conjunction with the grade of fuel oil carried, and, while not in themselves arbitrary, may be said definitely to apply to the grade of fuel carried in this case, viz., of a specific gravity varying within the limits 0·93 to 0·96.

Smoke observation glass doors are provided in each uptake, and the smoke conditions may at any time be observed from the floor plates. This is effected by means of a system of oblique mirrors which, in effect, function on the principle of a periscope, greatly facilitating this observation. A pyrometer is also embodied in each uptake by which the temperature of the uptake gases is ascertained and the proportion of CO_2 in the gases of combustion is accurately recorded by the "W.R." CO_2 indicator. With the grade of the fuel, the pressure and the temperature fixed within very minute limits and all furnaces receiving equal proportions of air, the desired readings (which experience shows to give the best results) may be obtained on the several apparatus by varying the quantity of air to be mixed with the fuel. With this grade of fuel and with suitable burner tips, the best conditions of combustion are obtained with a temperature and pressure of 250° Fahr. and 80 lb. per square inch, respectively, at the burners; an uptake temperature of 480°-500° Fahr.; 12-13 per cent. CO_2 in the flue gases, and with only a light grey smoke visible.

Precautions against Fire.

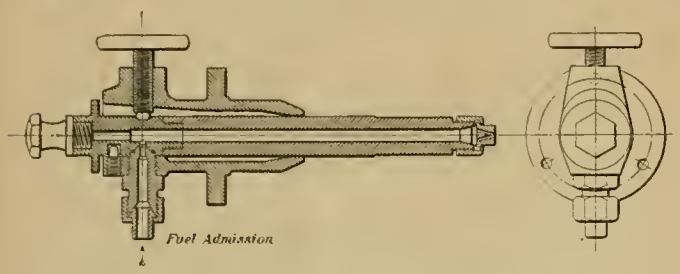
The increased risk of fire under oil-burning conditions is well known, and in the lay-out of the new installation every effort has been made to eliminate all danger of fire. It is noteworthy that, with the exception of pump glands and other essential glands in way of stop and sluice valve spindles, there are no glands in general use, so that leakage from this source is reduced to the minimum. Sheet-iron guards have been fitted to the combined heating and pumping units so that any leakage or splashing of oil from the oil pump glands cannot be a source of danger. Should any leakage take place from the fore and aft overflow pipe or from any upper connection to the wing tanks, or in the riveting or caulking of these tanks, sheet guards, carried well up the sides of the wing boilers, prevent such leakage falling on the boiler tops, and deflect the oil to the gutterways running fore and aft on the tank top. These gutterways connect at the after end of each boiler room with bilge hats set into the tank top, and from these hats the oil bilge pumps draw. Under each furnace door a sand-filled tray is provided so that any leakage from the burner or connections, either under service conditions or when a burner is being removed for cleaning, may be retained. A special vice has been designed by Mr. Balmer, of the Cunard Company, so that when removing burner tips, conveniently arranged drip-pans prevent any oil gaining access to the floor plates. An entire re-arrangement of the stokehold floor has been effected whereby open spaces are provided at the boiler fronts and at the bulkheads so that the presence of any oil in the tank tops is readily observed. In the event of any accumulation of oil taking place under the boilers the danger arising from the generation of fumes has been foreseen, and in both wings of each stokehold a ventilating duct has been fitted. This duct connects with a fan at its upper end and leads under the boiler at its lower end, so that a steady upward current of air is maintained.

Separate calorifiers have been installed, and a complete system of hot salt water piping supplies each stokehold. Flexible hose is led to the hydrants, and whenever and wherever necessary it will be the duty of each watch to maintain the tank tops in a state of immunity from oil. To facilitate the detection of oil in the tank top spaces and under the boilers these spaces have been coated white.

Fire-Fighting Arrangements and Appliances.

Very complete fire-fighting arrangements have been made. Portable chemical fire extinguishers are provided at various points in the stokeholds, and these, together with a liberal supply of sand, are capable of overcoming minor outbreaks. Under the boilers and in way of the furnace fronts a perforated steam pipe runs the entire width of the stokehold in accordance with the requirements of the Board of Trade, and this may be controlled from the stokehold, or alternatively, from "E" deck. A large capacity "Foamite" installation is provided on "F" deck, and some idea of the size of the motor-driven pumping plant will be obtained from the photograph on page 140. Two tanks containing "A" and "B" solutions are also provided on "F" deck, and separate discharge pipes lead from the pumps to every section of the stokehold. The "A" solution contains a chemical which gives an acid reaction, and the "B," or basic solution, contains a salt very rich in carbon dioxide, and, in addition, "Foamite." This latter is a vegetable

compound, and when the "A" and "B" solutions interact, carbon dioxide is given off in great volume. The function of "Foamite" is to seal the effervescent bubbles and prevent the escape of CO_2. The resulting froth assumes a volume eight times that of the combined original volume of the two solutions, and in this froth no flame can live. The twin pipes are led to each section of the stokehold so that the foaming effect is not reduced by the surface friction of a long length of piping, but is developed as near the source of the fire as possible. A reel, mounted on hollow trunnions, carries a hose of sufficient length to reach any part of the boiler room, or alternatively, the adjacent boiler room. When the fire-alarm is given the "Foamite" motor-driven pumps are started by pressing an electric button on the starting platform in the



Section through Wallsend-Howden Burner.

engine room, and to such a point has the efficiency of fire drill been brought that it is estimated a period of less than two minutes will only elapse before the foam solution reaches the seat of the fire. The installation is of such capacity that, if necessary, a foam film of 32 in. in depth can be deposited at any point in any stokehold.

Should it be necessary to vacate any boiler room owing to the intensity of the fire, means are provided for completely shutting off all air admission. In addition, extension rods are carried up to "E" deck so that the following may be effected:

(*a*) The fuel pumps may be shut down.

(*b*) The suction valves to settling tanks may be closed.

(*c*) The steam fire-extinguishing apparatus may be brought into operation.

In accordance with the requirements of the Board of Trade, extension rods are led from all valves situated near the bottom of the storage tanks so that these valves may be operated from the deck above and outside the boiler rooms, which is, in this case, "E" deck. These extension rods function through bevel gearing, are led through the fore and aft wing bulkheads, and carry hand wheels suitably marked to their station. These hand wheels are grouped and totally enclosed in a locked casing, access to which cannot be gained without the knowledge of the chief engineer.

General Renovation and Reconditioning.

Concurrently with the work of conversion as already described, opportunity was taken to introduce several new features in the accommodation, and also to overhaul the main and auxiliary machinery. All the furnishings in the public rooms have been modernised, and the magnificent panelling and carving which adorns the ship has been renovated. The state rooms have been relaid with new carpets, and additional private bathrooms have been provided in the state room accommodation. Main and auxiliary machinery were surveyed by the Board of Trade. Two low-pressure ahead turbines and one low-pressure astern turbine were opened up for examination, rotors were raised, and all blading clearances were adjusted. Feed pumps and all items of auxiliary machinery were opened up and thoroughly overhauled. It is not too much to say that the reconditioning and modernising of this vessel will give her a new lease of life and will still further increase her popularity with the ocean-going public.

To some minds the conversion of a vessel of this size from coal to oil-burning has conjured up extravagant visions of speed records. It should, however, be borne in mind that, although more steam will admittedly be generated than hitherto, the capacity of the engines for utilising this steam is as before. The regularity of the steam supply, however, will be a decided advantage, and should be reflected in the average speed for the voyage. On this reasoning it is not without the bounds of possibility, despite the fact that the vessel is 15 years old, that her record average speed of 25½ knots across the North Atlantic for 27 consecutive runs will be improved upon in the near future. It is interesting to recall that on the fastest run made between Queenstown and New York a speed of 26·06 knots was averaged with coal-burning. The whole oil-burning installation has been effected in accordance with the requirements of Lloyd's Register and the Board of Trade.

We wish to express our indebtedness to the Cunard Company for the facilities placed at our disposal for photographing the installation on the *Mauretania*, and to Mr. J. Austin, Superintending Engineer of the Line, Mr. A. Cockburn, R.D., R.N.R., Chief Engineer of the *Mauretania*, and others for their assistance.

OIL-BURNING STEAMERS AND THE SMOKE NUISANCE.

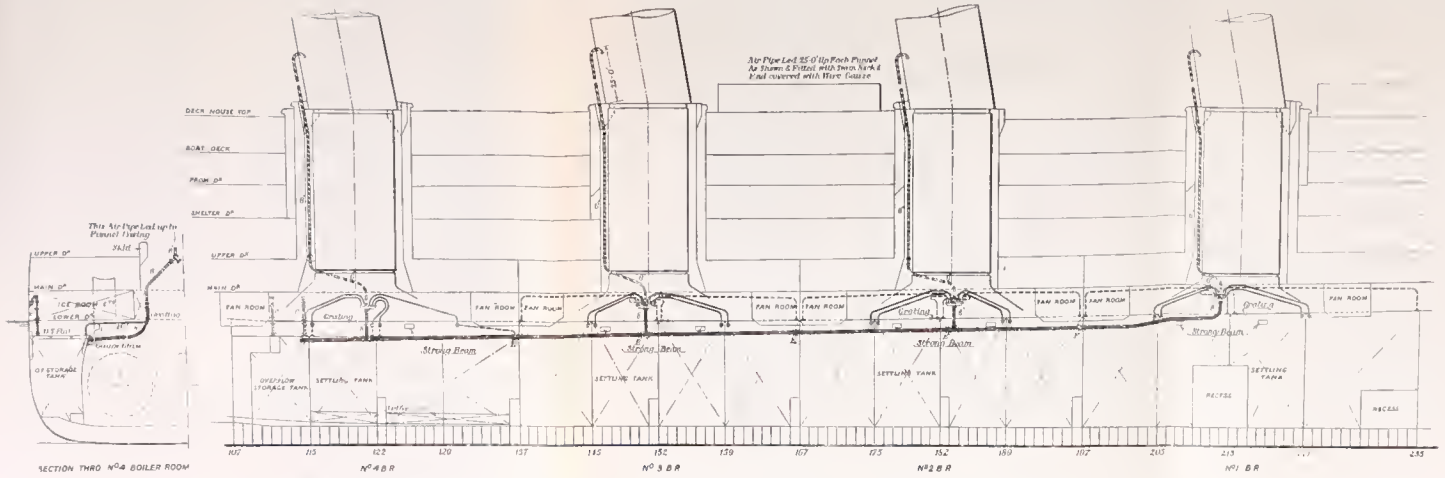
The extensive adoption of oil fuel on board ship has brought in its train several disadvantages both from the point of view of the engineer in charge and of the general public. No penalties were exacted from the engineer who, in a coal-burning vessel, elected to pump out the bilges after the ship had been moored alongside the dock. This very convenient method of working off excess boiler pressure following a sudden "finished-with-engines" is no longer available to the engineer on an oil-burner, who must perforce clear all his oil-impregnated bilge water from the ship before she enters the controlled waters of any of the world's ports.

In the fifteenth annual report recently received from the Bengal Smoke Nuisances Commission, attention is directed to this phase of oil-burning on board ship. The questions of fuel economy and prevention of smoke cannot be dissociated and in a marine boiler furnace the atomisation, pressure and temperature of the oil fuel, and the distribution of the air supply, are vital factors in arriving at efficient combustion. In their efforts to effect a reduction of the canopy of smoke and oily soot frequently emitted by these vessels in port, the Commission find that while the average engineer takes pains to ensure that all the factors essential for efficient combustion are properly combined while the vessel is at sea, there nevertheless exists a certain laxity on their part in regard to similar considerations affecting the control and operation of auxiliary boilers for port use.

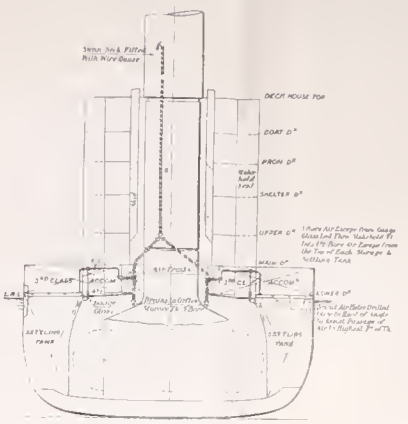
A spirit of friendly co-operation has been established as between the Commission and the several ships' engineers, and in the case of a regular line of Liverpool-owned steamers trading to the port, three of their new oil-burning steamers have been altered in accordance with the recommendation of the Commission. These alterations were confined to the auxiliary boiler equipment, and it is stated that not only has the smoke been practically eliminated, but the chimney losses have been substantially reduced and a saving of 20 per cent. has been realised in the fuel consumption.

The Premier Electric Welding Company Limited. – With a view to increasing the efficiency of this firm's organisation, it has been decided to concentrate a number of their departments in the London area. Arrangements have been made to transfer the head office, technical and research laboratories and electrode factory, and all communications should now be addressed to the Premier Electric Welding Company Limited, Abbey Wood, London, S.E.2.

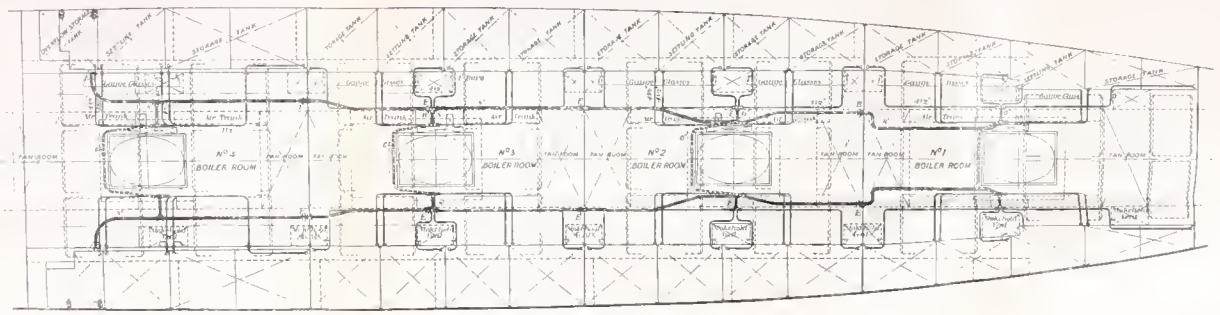
PIPING ARRANGEMENTS OF THE OIL FUEL SYSTEM ON THE CUNARD LINER "MAURETANIA."



SECTION THRO No 4 BOILER ROOM



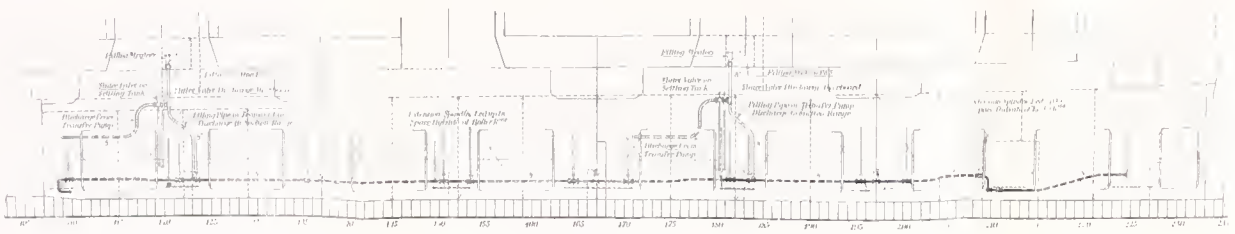
SECTION THRO No 2 BOILER ROOM FRAME 182



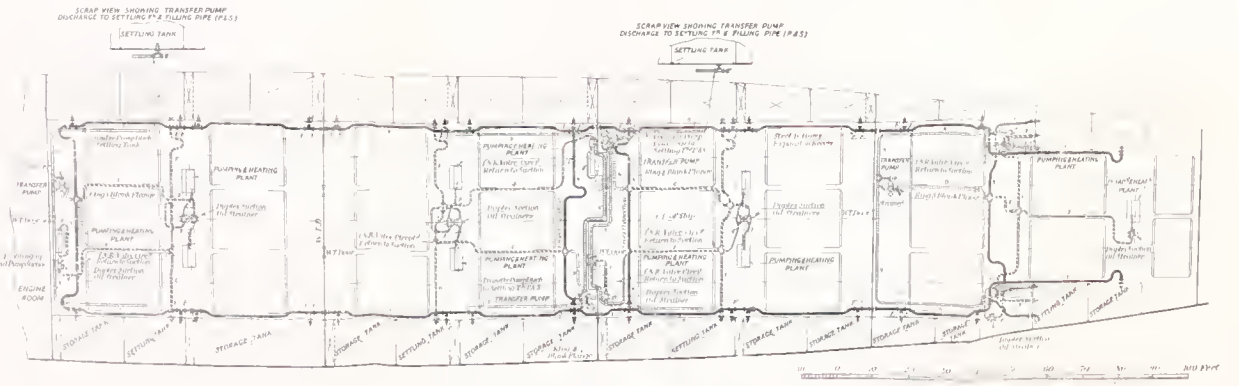
DIAGRAMMATIC ARRANGEMENT OF AIR & OVERFLOW PIPES FROM OIL STORAGE TANKS

Air & Overflow Pipe
Air Escape Pipe

EXPANSION PIECES MARKED "E"
(Material Steel)



SECTION THRO No 4 BOILER ROOM


SCRAP VIEW SHOWING TRANSFER PUMP DISCHARGE TO SETTLING TK 2 FILLING PIPE (P 45)
SETTLING TANK
SCRAP VIEW SHOWING TRANSFER PUMP DISCHARGE TO SETTLING TK 6 FILLING PIPE (P 45)
SETTLING TANK
PUMPING & HEATING PLANT
TRANSFER PUMP
ENGINE ROOM
STORAGE TANK
SETTLING TANK

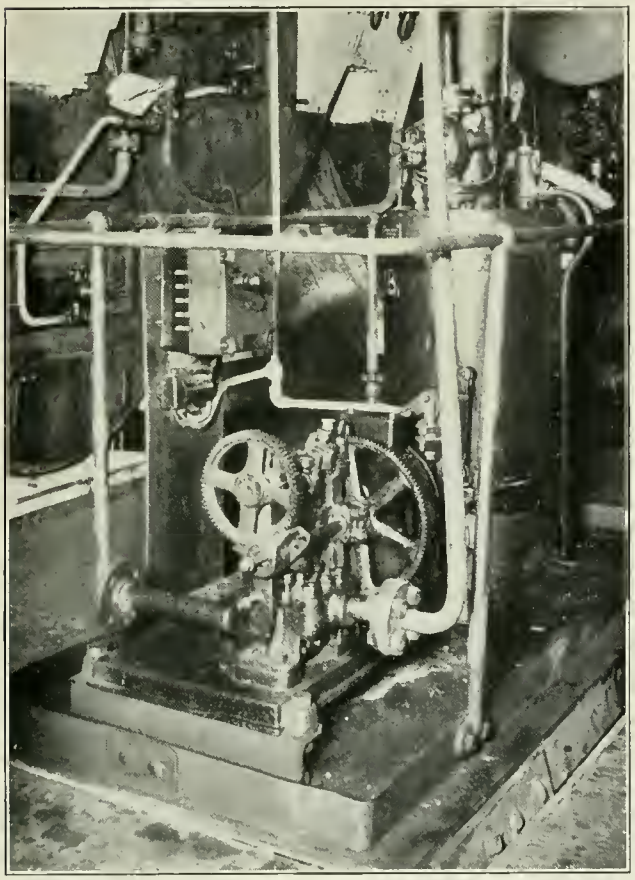
DIAGRAMMATIC ARR OF O.F. SUCTION FILLING & TRANSFER PIPES IN BOILER ROOMS

Main Suction & Filling Range
Pressure Pump Suction from Settling & Storage Tanks
Transfer Pump Discharge to Settling Tanks
Storage
Suction from Storage
Filling from Hose
Through Filling Pipes

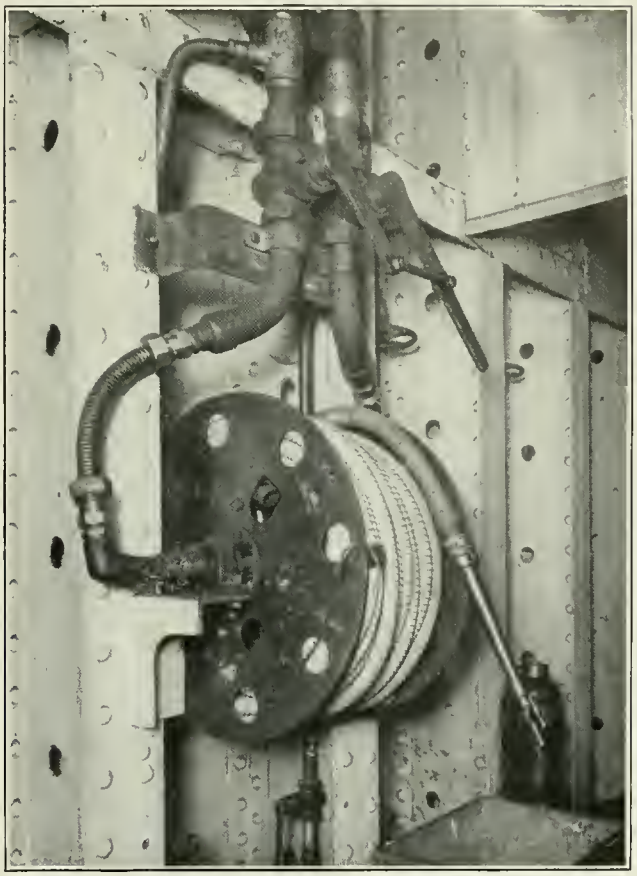
pains to ensure that all the factors essential for efficient combustion are properly combined while the vessel is at sea, there

now be addressed to the Premier Electric Welding Company Limited, Abbey Wood, London, S.E.2.

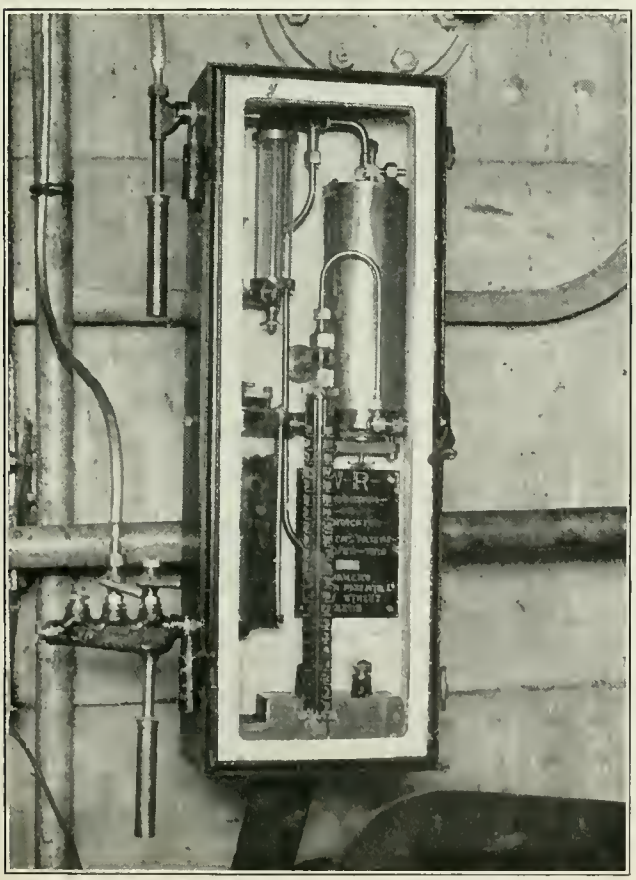
OIL-FUEL INSTALLATION ON THE CUNARD LINER "MAURETANIA."



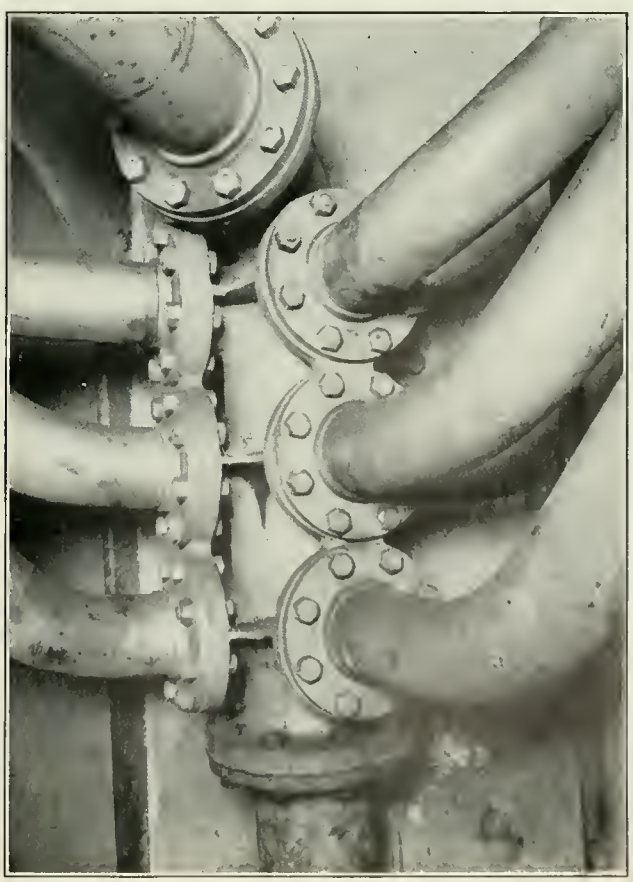
Emergency Starting Set, No. 4 Stokehold, Centre Section.



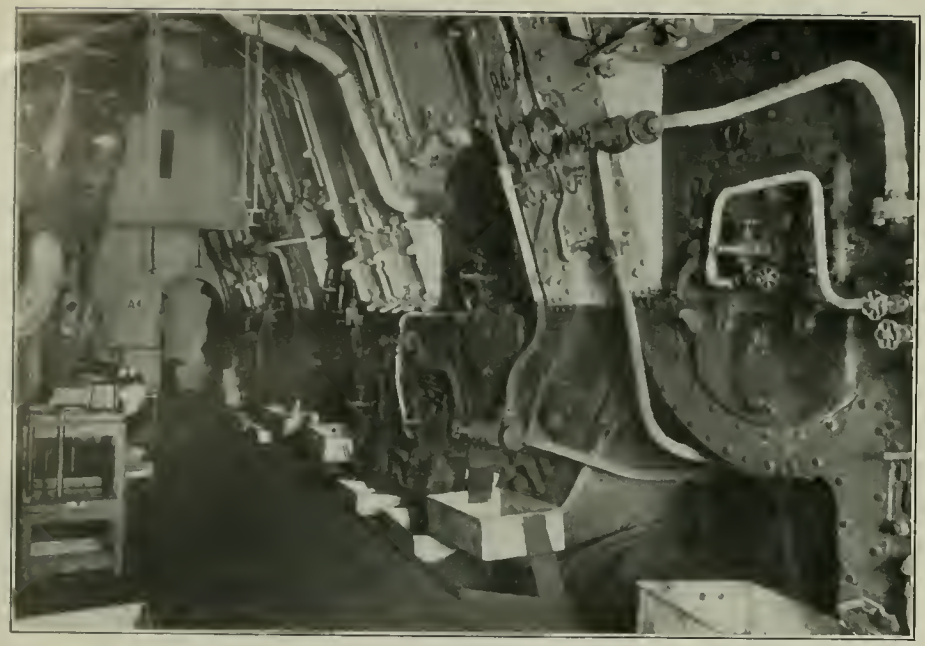
"Foamite" Fire-Extinguishing Control and Distribution Reel Mounted on Hollow Trunnions.



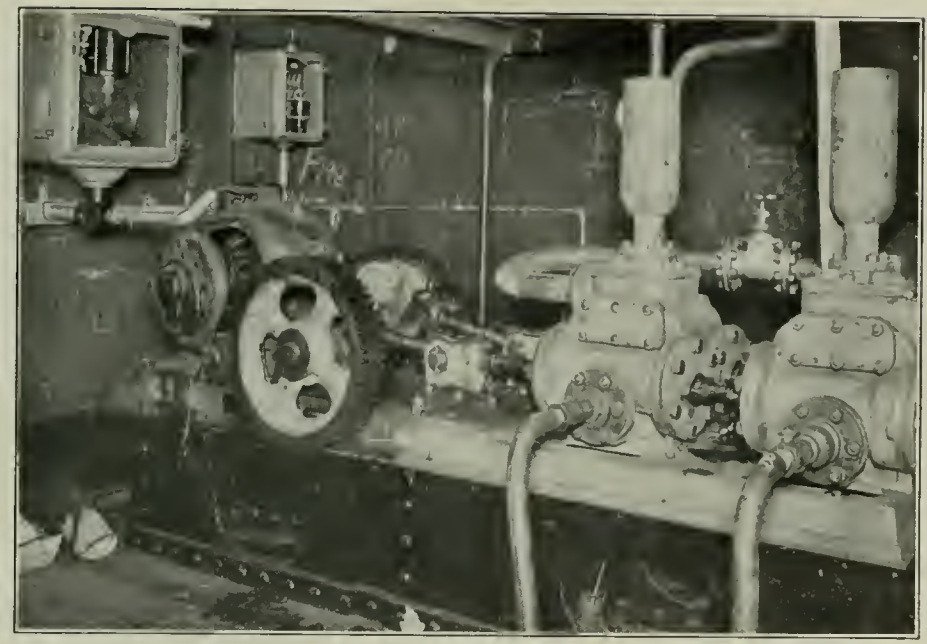
"W.R." CO_2 Recorder, No. 3 Stokehold, Centre Section.



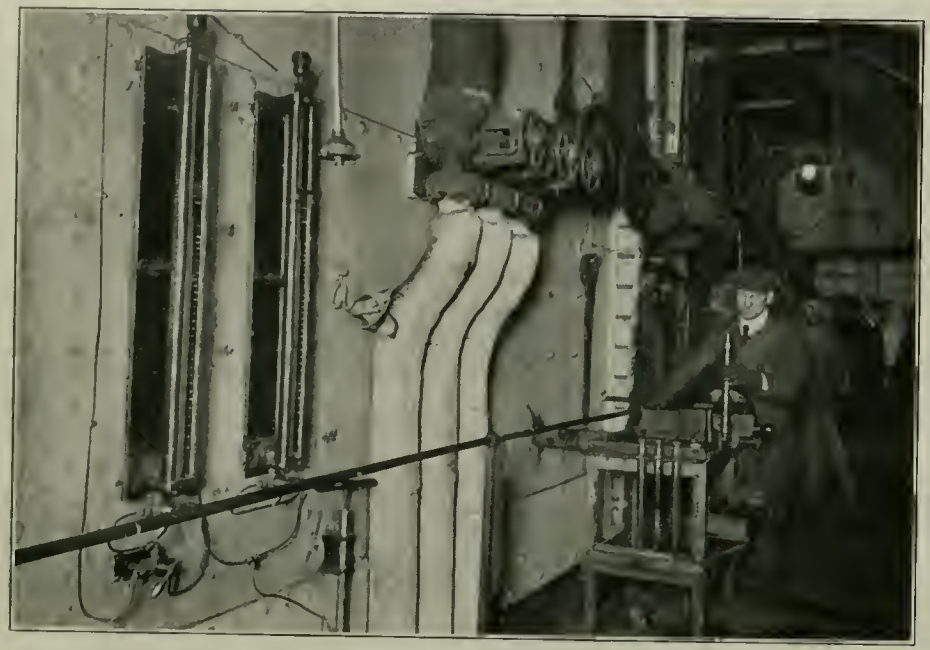
Overflow Junction Piece and Air Escape to Funnel Casing.



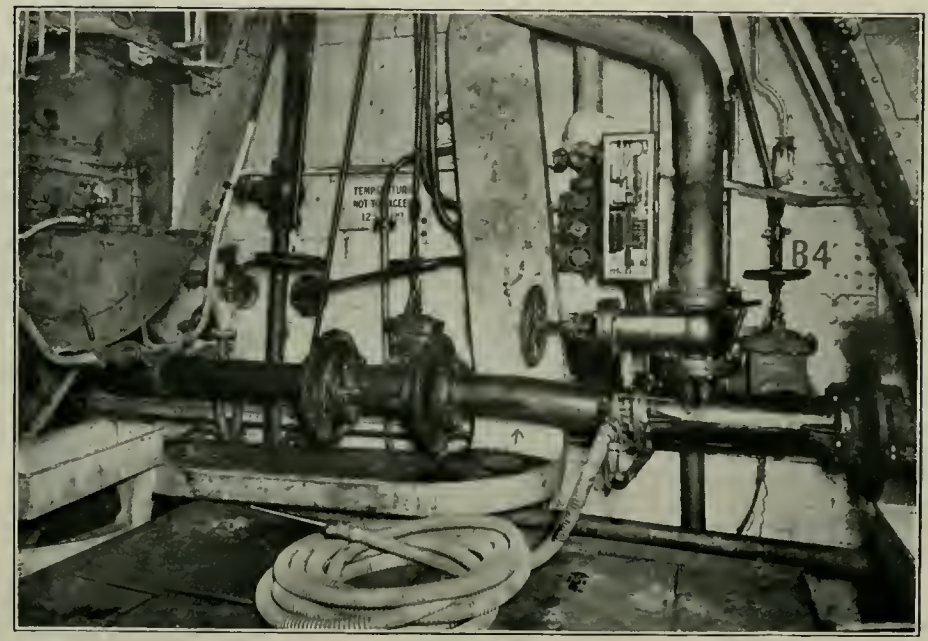
No. 4 Stokehold Single-End Section, showing Furnace Fittings and Drip Trays.



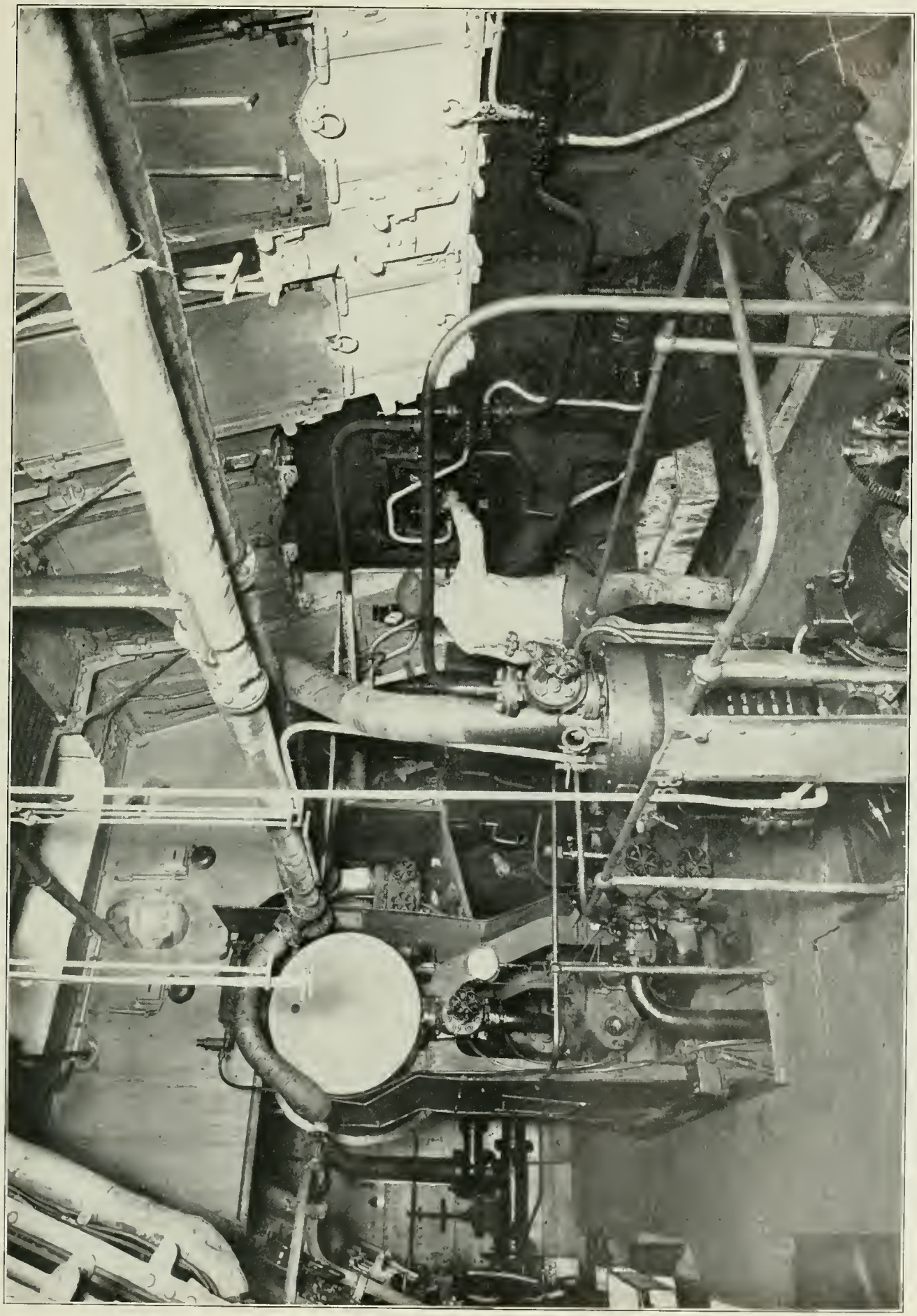
Motor-driven Pumps ("F" Deck), showing "A" and "B" Suctions of the "Foamite" Installation.



No. 2 Stokehold Forward, Single-End, showing Pneumercator Gauges and Equilibrating Hand Pump, also Balmer Vice for Burners.



No. 4 Centre Stokehold showing Filling Main; "Bellows" Expansion Piece; Hot Salt-Water Hose; Ventilating Duct, and Sluice Valve Extension Rods.



The Oil-Fuelled "Mauretania." No. 4 Stokehold, Centre Section, showing Wallsend-Howden Combined Heating and Pumping Unit, also Motor-driven Emergency Starting Set in Foreground. View looking to Starboard.

MANUFACTURE OF THE DOXFORD OPPOSED-PISTON OIL ENGINE IN THE UNITED STATES OF AMERICA.

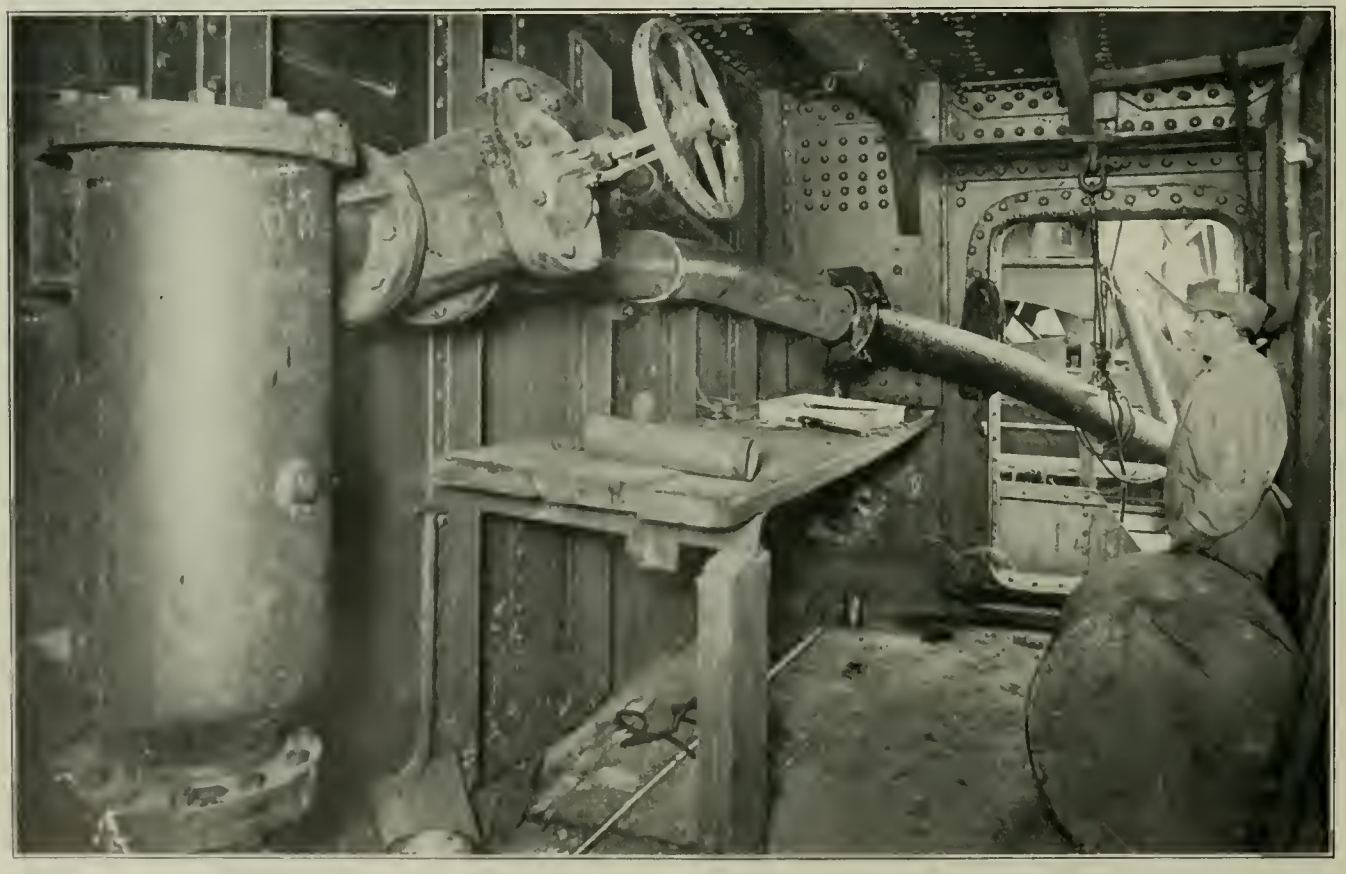
Important developments have recently been concluded in connection with the manufacture of internal-combustion engines of the above type in America, William Doxford & Sons Limited, of Sunderland, having agreed with the Sun Shipbuilding Company, of Chester, Pennsylvania, U.S.A., uniting the interests of the American Junker Patents with the Doxford Patents, which have been the basis of the developments forming the Doxford opposed-piston oil engine.

After filling Station on the "Mauretania," Port Side. View taken from Deck of Fuelling Barge.

The Sun Company, of Chester, have already secured the full licence for America and its possessions, of the Junker Patents, and will operate both interests in America.

An immediate start is to be made at the Chester works on the construction of 4-cylinder 3,000 h.p. single-screw installations, being repeats of Doxford's manufacture, two of which are already at sea in the motor ships *Yngaren* and *Dominion Miller*.

Further repeats are in hand at Sunderland, and arrangements have been made for similar engines at the Belfast works of Workman, Clark & Co., and also on the Clyde at the works of the Fairfield Shipbuilding & Engineering Company Limited.



After filling Station on the "Mauretania," Port Side, showing Filter, Sluice Valve, and Outboard Flexible Hose.

M.V. "LOUISIANA," 9,960 TONS D.W.

Built by the Ardrossan Dry Dock & Shipbuilding Company Limited, and fitted by the Builders with Engines supplied by Burmeister & Wain, Copenhagen.

The twin-screw motor vessel *Louisiana*, which has just sailed from Barry on her maiden voyage to the River Plate with a cargo of coal, has been built by the Ardrossan Dry Dock & Shipbuilding Company Limited, to the order of the United Steamship Company, of Copenhagen, and is a fine example of a modern Diesel-engined cargo vessel.

Dimensions.

The principal dimensions of the *Louisiana* are as follows :—

Length, between perpendiculars	405 ft. 3 in.
Breadth, moulded	55 ft.
Depth, moulded to upper deck	27 ft. 9 in.
Depth, moulded to shelter deck	36 ft. 6 in.
Block coefficient to load draught	0·772.
Deadweight, including bunkers	9,960 tons.
Gross tonnage	6,512·87 tons.
Net tonnage	4,046·15 tons.
Displacement, loaded	13,858 tons.
Draught, loaded	28 ft. 1 in.
Horse-power of main engines	2,800 i.h.p.
Speed on trial	11¾ knots.

The vessel is of the closed shelter deck type with complete steel deck below, and with a steel orlop deck forward. There is a double bottom running for the entire length of the hull, and fitted for the carriage of either oil fuel or water ballast, the oil fuel capacity being 956 tons at 40 cub. ft. per ton, while in addition there is a portion reserved for fresh water, and having a capacity of 247 tons, and a portion for lubricating oil with a capacity of 13½ tons. The total water ballast capacity, including the peak tanks, is 1,437 tons of salt water.

A coal bunker is provided for galley purposes having a capacity of 26 tons at 45 cub. ft. per ton, while the capacity of the domestic tanks is 30 tons. For working the cargo in and out of the holds five large hatchways have been fitted in addition to the tonnage hatch, these all being 25 ft. 8 in. long by 16 ft. wide, with the exception of No. 2 hatch, which is made larger for dealing with particularly bulky cargo, being 30 ft. 4 in. long by 16 ft. wide.

For working the heavy cargo a derrick of 15 tons capacity is carried, there being in addition two 3-ton derricks and eight 2-ton derricks, which on double purchase are capable of lifting loads of 4 tons.

The cargo winches, 11 in number, which have been supplied by Clarke, Chapman & Co., are all electrically driven, eight of these being of 3 tons capacity, and three of 4½ tons capacity. The capacity of the holds is given in the following table :—

	Grain.	Bales.
Holds	375,100	346,300
'Tween decks	149,900	134,300
Total cubic feet	525,000	480,600

Propelling Machinery.

The propelling machinery consists of two sets of Diesel oil engines built by Burmeister & Wain at Copenhagen. It was originally arranged that the vessel, when launched, should be towed to Denmark for installation of the machinery, but subsequently the owners agreed with the builders to send the main propelling machinery to Ardrossan and have it fitted up by the builders. Each engine consists of six cylinders operated on the four-stroke cycle, the diameter of the cylinders being 590 mm. (23¼ in.), and the piston stroke 900 mm. (35½ in.), and developing 1,400 i.h.p. at a speed of 140 r.p.m.

Auxiliaries.

The auxiliary machinery, as well as the deck machinery, is electrically operated, current being supplied by three generating sets, each comprising a two-cylinder non-reversible Diesel engine by Burmeister & Wain, direct coupled to a dynamo of 60 kw. capacity, the pressure of the supply being 220 volts. There are two motor generators, each of 25 kw. capacity, which supply current for lighting purposes, and among the electrically-driven auxiliaries there is one auxiliary air compressor, two water-cooling pumps, one ballast pump, and two pumping sets comprising a bilge and a sanitary pump driven by the same motor, one oil transfer pump, four lubricating oil pumps, and one fresh water pump. There is an oil-fired vertical donkey boiler, 4 ft. 6 in. diam. and 11 ft. high, having a working pressure of 100 lb. per square inch, which serves, among other things, a small reserve compressor. The feed pump for the donkey boiler is also steam driven.

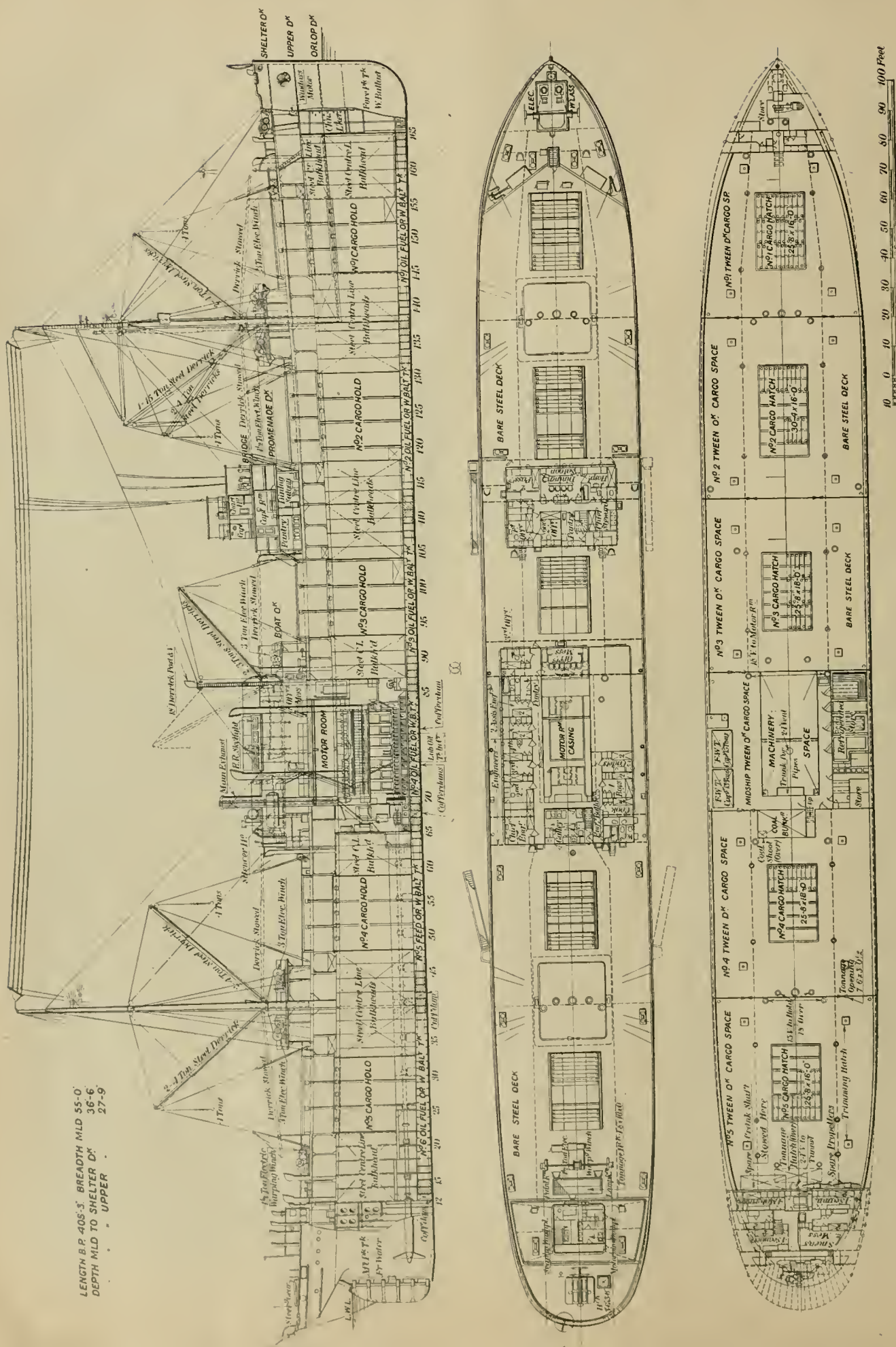
Electrical Installation.

The electrical installation work has been done by Telford, Grier & MacKay Limited. The switchboard is of marble, bolted to a suitable frame fitted at the forward end of the engine room, and having panels for the 220-volt power generators and for the 100-volt lighting dynamos. From the switchboard feeders are run to the windlass, winches and the steering gear on deck, to all the electrically-driven machinery in the engine room and to the wireless telegraphy apparatus in the wireless room.

The steering gear, of the Hele-Shaw Martineau electric hydraulic type, has been supplied by John Hastie & Co. Ltd. There is a forged steel tiller actuated by two hydraulic rams, the hydraulic pressure being generated by a Hele-Shaw pump driven by an electric motor. One of McTaggart, Scott & Co.'s latest telemotors is fitted. The ship's provisions are carried in four insulated rooms, the refrigerating machinery and ice-making plant having been supplied by Messrs. Sabroe's, of Copenhagen.

In addition to the accommodation of the officers, engineers and crew, consisting of 39 men all told, there is accommodation for five passengers in single and double berth rooms.

The *Louisiana* was launched in October last, and the fitting of the machinery commenced a week or two afterwards. The vessel left Ardrossan under her own power on March 10 for drydocking at Glasgow, after which the trials were run on March 17. A mean speed of 11¾ knots was obtained on the measured mile, and the entire machinery worked without a hitch. A few days afterwards the vessel left for Barry Docks to load coal for the River Plate.


SHELTER D.K
UPPER D.K
ORLOP D.K
LENGTH B.P. 405'-3" BREADTH MLD 55-0"
DEPTH MLD TO SHELTER D.K 36-6"
" " UPPER " 27-9"
BRIDGE
PROMENADE D.K
BOAT D.K
MOTOR ROOM
No1 CARGO HOLD
No2 CARGO HOLD
No3 CARGO HOLD
No4 CARGO HOLD
No5 CARGO HOLD
No1 OIL FUEL OR W.BALT TK
No2 OIL FUEL OR W.BALT TK
No3 OIL FUEL OR W.BALT TK
No4 OIL FUEL OR W.B.TK
No5 FEED OR W.BALT TK
No6 OIL FUEL OR W.BALT TK
BARE STEEL DECK
No1 TWEEN D.K CARGO SP
No2 TWEEN D.K CARGO SPACE
No3 TWEEN D.K CARGO SPACE
No4 TWEEN D.K CARGO SPACE
No5 TWEEN D.K CARGO SPACE
MIDSHIP TWEEN D.K CARGO SPACE
MACHINERY SPACE
No1 CARGO HATCH 12'-8" x 16'-0"
No2 CARGO HATCH 30'-4" x 16'-0"
No3 CARGO HATCH 25'-8" x 18'-0"
No4 CARGO HATCH 25'-8" x 18'-0"
No5 CARGO HATCH 25'-8" x 16'-0"
MOTOR R.M CASING
Trimming Hatch
Stern Tube
Stern Frame
Rudder
Propeller
Tonnage Opening
0 10 20 30 40 50 60 70 80 90 100 Feet

M.V. "Louisiana" Built by the Ardrossan Dry Dock & Shipbuilding Company Limited, and Engined by Burmeister & Wain Diesel Engines for the United Steamship Company of Copenhagen. (*See page* 145.)

DEVELOPMENTS IN THE DESIGN OF MARINE OIL ENGINES.—II.

Built, Solid, and Partly Built Crankshafts—Trend of Column and Framing Design—Two and Four Stroke Pistons and Cylinder Covers—Piston Clearances and Methods of Cooling.

In considering the detail design of oil engines, it must be remembered that an oil engine has to withstand heat and pressure conditions far in excess of anything ever contemplated in steam engine construction, and it is a matter of course to find the standard of design and manufacture very much higher than in the average reciprocating steam engine, where pressures are comparatively low and the heat conditions practically negligible. This, of course, involves higher expense in the manufacture of oil engines, but is to some extent countered by the fact that oil engines are built up of similar units throughout, and accordingly lend themselves to mass production, all parts being manufactured to jig.

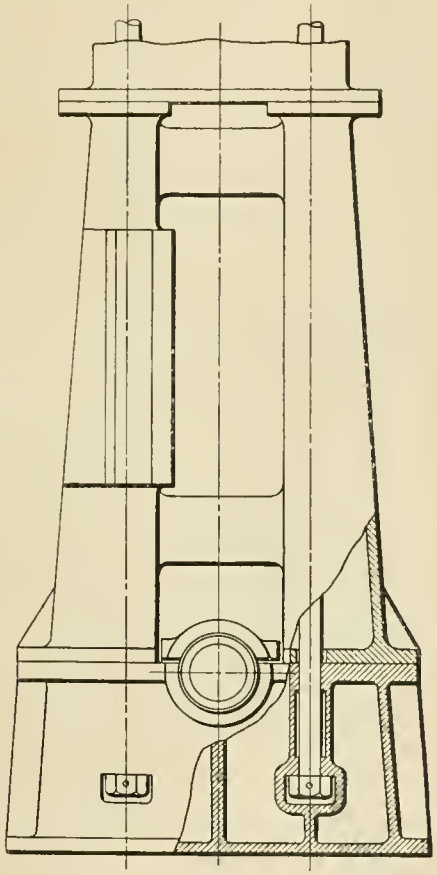


Fig. 1.

Too much importance cannot be placed upon the design of the crankshaft, and careful investigation is essential. While the designer is controlled in fixing a minimum size by the rules of the various classification societies, each of which has its own formula for the purpose, the designer must also take into consideration the particular engine and purpose for which it is required. Twisting and bending moment diagrams should be prepared for each case, and the shaft designed to withstand the stress thus ascertained, apart altogether from the formal minimum called for by Lloyd's and similar rules. A point which is sometimes overlooked, and which has from time to time proved to be a source of trouble, is the question of torsional vibration, with the flywheel and the line shafting, as the consequences of the natural frequency of the shaft coinciding with that of the impulses caused by the working strokes would be very serious. This subject is one which has given rise to several investigations, and while it is now possible to approximate closely the possible conditions which will be experienced, finality does not appear to have yet been arrived at as to the most accurate method of calculating the stresses due to this condition or the critical speeds at which they may be expected.

The material used for the construction of crankshafts is generally ordinary mild quality steel with a tensile strength of 28 to 32 tons, although in the case of some high-speed engines for special purposes a high quality steel is used, or, upon occasion, where weight is an important factor, nickel-steel shafts are fitted. Diesel engine manufacturers seem to be fairly evenly divided in their views as to whether solid or built-up shafts should be adopted. While the solid shaft is more expensive than the latter, it offers advantages in being lighter, more suitable for resisting heavy loads, and permits of a low stroke-bore ratio being used. The built-up shaft requires great care in manufacture, the shrinking in of the crankpins and journals being an important feature, large dowel pins usually being fitted as additional security. The partly built-up shaft is a compromise between these two types, the crankpins being forged solid with the webs, and is usually adopted where a comparatively low stroke-bore ratio is desired, in which case the distance between the shaft body and the crankpin is not sufficient to withstand the bursting effect of the shrink.

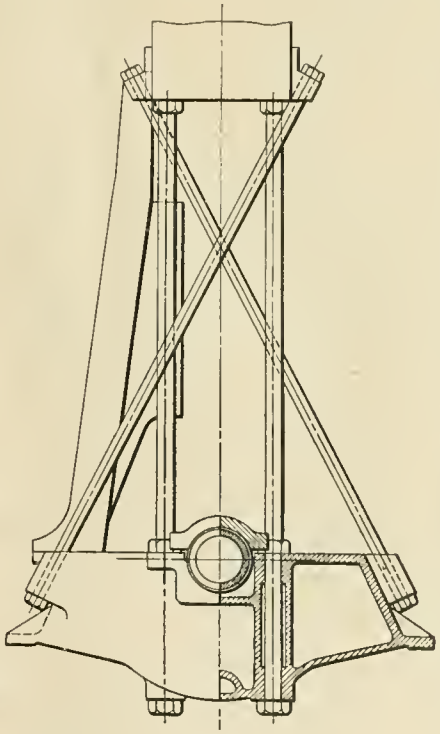


Fig. 2.

The ideal type of bedplate would appear to be that shown in Fig. 1, of the deep box section with a flat bottom, and arranged for bolting direct to the tank top without the necessity of making a specially built-up seat. This, however, is not always practicable, and the type shown in Fig. 2 is typical of bedplates adopted with built-up seatings. Care must be taken in the design of the bedplate to ensure that it is sufficiently stiff to take all loads due to the impulses of the engine, and to take care of any slight distortion of the hull of the vessel, particular attention being given to the securities at each end of the bedplate, which are perhaps more liable to show the effects of vibration than in the centre of the engine. The bottom of the bedplate is usually cast solid in the form of a tray to act as an oil well, and is provided with connections to the lubricating oil drain tanks. The main bearings are very much on the lines of steam engine practice, the shells being of cast iron, lined with white metal, care being taken to ensure close contact of the white metal with the shells at all points. For four-cycle engines, the cap must be capable of taking the inertia and centrifugal loads, but in the case of two-cycle engines the compression counteracts the inertia load, and caps are therefore made much lighter.

Considerable variation in the design of framing for mercantile engines is met with, three of the principal types being as shown in Figs. 1, 2 and 3, *i.e.*, the trestle, steel column and crankcase types. An important factor in framing design is to ensure that the whole of the impulse load can be safely transmitted through it to the bedplate. That this is no inconsiderable

item will be realised when it is considered that the impulse load due to a cylinder of 26 in. diam. is in the neighbourhood of 120 tons, which in the case of a four-stroke engine running at 100 r.p.m. occurs 50 times per minute.

The columns must also be designed to give stiffness to the engines, as the strain put upon them during stormy weather, with the vessel pitching and rolling, is very severe. The trestle type of framing shown in Fig. 1 straddles the bedplate athwartship, sitting over and being arched for the main bearings. To take the tensile stress due to the impulse load, steel tie bolts are fitted which pass through the full length of the framing, and are secured to the bedplate and to the tops of the cylinders independently of the columns, thus relieving the cast portion of the latter from any strain due to this cause. Crosshead guides are bolted between each pair of columns. Oil-tight casings, fitted with suitable handhole doors, are provided to bridge the columns in a fore and aft direction. This type of column offers an open construction of the engine, and is advantageous in affording accessibility to main bearings, &c., in case of overhaul. The arrangement of the steel column framing, as shown in Fig. 2, is more complicated than the cast column type, although somewhat lighter in weight, the vertical rods connecting the cylinders to the bedplate carrying the impulse loads only, separate diagonal rods being fitted to obtain rigidity. The lateral thrusts from the crossheads are taken by cast columns specially fitted for this purpose. The arrangement makes a very accessible engine, but the fitting of oil-tight casings is a somewhat difficult problem. The crankcase type of framing shown in Fig. 3 is the type generally adopted for high-speed engines as used for marine electric light Diesel engines, and is generally on the lines of that fitted in the standard German submarine engines. The whole of the stresses are, in this design, transmitted from the cylinder covers direct through the cast framing to the bedplate, and great care therefore must be exercised in the design and manufacture. An advantage is gained in obtaining ideal oil-tight casings, but accessibility to bearings, &c., is very difficult.

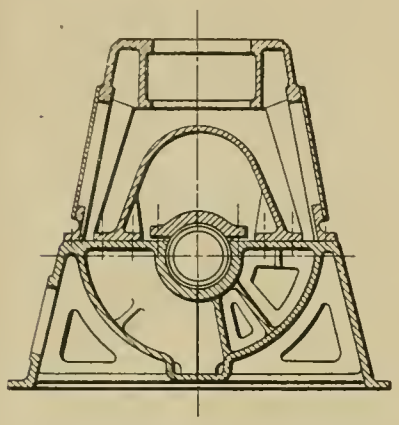


Fig. 3.

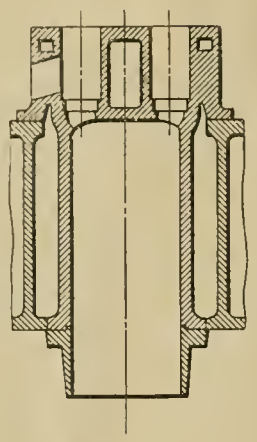


Fig. 4.

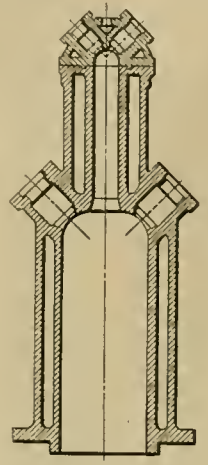


Fig. 6.

Fig. 7.

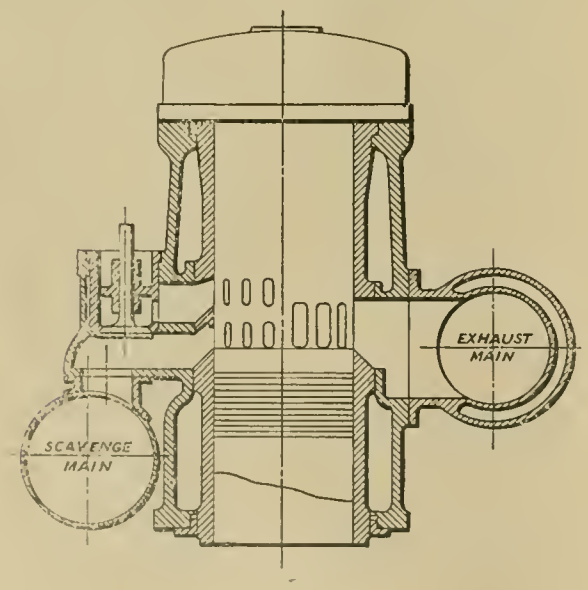


Fig. 5.

Cylinder design has long been the subject of wide discussion. Present-day practice is to cast the liners and jackets separately, although in one case, as shown in Fig. 4, the liner is cast integral with the cover. The liners are designed to withstand the bursting pressure due to the gas pressure, and the heat stresses due to temperature differences. Where through bolts from the tops of the cylinder covers to the bedplate are not fitted, as in the case of engines with the crankcase frames, the cylinder jacket must be designed to take the full stress due to the impulse loads. The liners are made of special close-grained hard cast iron, and are turned inside and outside to ensure uniformity of thickness of material in order to avoid unequal stresses. In some cases the bore of the cylinders is ground to obtain accuracy of finish and to ensure equal wear, but with present-day experience it is doubtful if the advantages gained by this are worth the additional labour and expense involved. Security of the liner to the cover is made by a flange at the upper end, which end also carries the spigot of the cylinder cover. The lower end is arranged so as to be free to expand in a downward direction, either a short stuffing-box or a sliding rubber joint being fitted between the liner and the jacket to prevent leakage of cooling water. In the case of two-cycle engines, the liners are fitted with exhaust or scavenge ports, or both, corresponding to the exhaust or

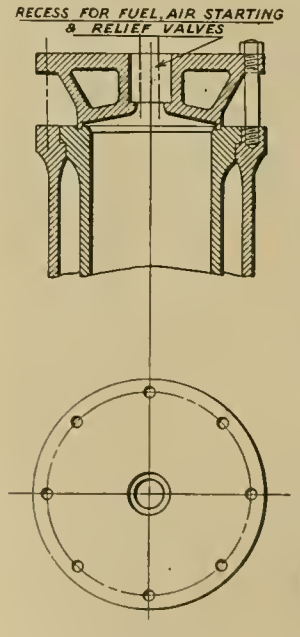


Fig. 8.

scavenge belts in the jackets. These ports in certain engines extend practically the full diameter of the cylinder, bars connecting the upper and lower portions of the liner being arranged, which also prevent the piston rings fouling the ports. In order to facilitate the entering of piston rings, and to prevent a formation of a ridge on the liner where the top piston ring finishes when the piston is on the top centre, all liners are bell-mouthed at the top. The cylinder jackets for four-stroke engines are comparatively simple, and if made separately for each cylinder, are bolted together, and correspond more or less in arrangement with those shown in Fig. 4, in which the jackets are shown cast in the form of an entablature. Two-stroke cylinder jackets as shown in Fig. 5, however, with their exhaust and scavenge belts, and sometimes with scavenge valve pockets, are a more difficult proposition, and offer problems not only to the designer but also to the foundry, although in the present state of the art, it must be admitted that comparatively little difficulty is experienced with these castings on actual services. Fig. 6 shows the usual type of compressor cylinder which is fitted with stepped piston.

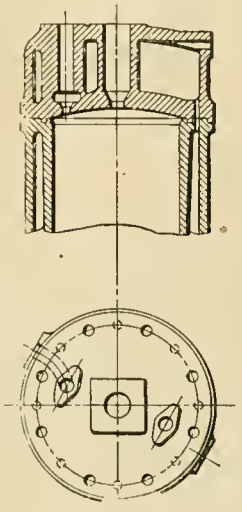


Fig. 9.

The designing of the cylinder cover in a modern Diesel engine calls for the utmost skill of the designer as this part of the engine is called upon to carry the most severe stresses met with in the design. The whole of the load due to the gas pressure is to be carried, and passed through the tie bolts or framing to the bedplate. The cover must also be sufficiently stiff not only to carry the load, but to prevent distortion which would possibly react upon the valve seats, one of the least consequences of which would be serious leakage.

Unequal expansions of the various parts of the cover due to the extreme temperature conditions is a serious factor, while the problem is further complicated, especially in the four-stroke design, by the valves required to be carried in it. Perhaps the worst case to be considered is the four-stroke engine, where the fuel, exhaust, inlet, air starting and relief valves are carried (Fig. 7). On the other hand, the simplest case is that of the Still engine, where only one valve, *i.e.*, the fuel valve, requires to be accommodated. The valves are fitted as symmetrically as possible in the cover, with a view to minimising the difficulties to be expected in the question of unequal expansion, and the closest approach to the ideal in this respect is reached in the latest two-cycle Sulzer cover (Fig. 8), in which the cover is a very simple symmetrical casting, arranged to carry a central cage in which is fitted the fuel, air starting and relief valves, the exhaust and scavenging being arranged through ports cut in the liner. Numerous failures of this important casting were reported in the early stages of the Diesel engine, but these have become fewer as foundry knowledge of requirements has progressed, although some firms still adhere to the practice of fitting separate wrought steel plates either at the top or at the bottom of the cover, to ensure satisfactory castings, and free cooling water passages which are rather restricted where a multiplicity of valves are fitted. Uniformity of the type of joint between the cover and the liner has not been reached, copper or copper-covered asbestos being favoured by some firms, while others make a metal-to-metal joint. Fig. 9 shows another type of two-cycle cover with fuel, air-starting and relief valve therein.

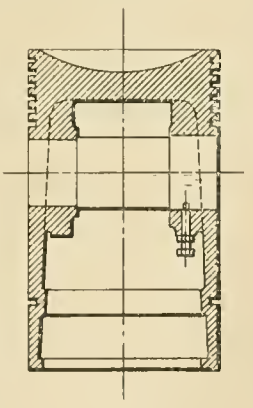


Fig. 10.

Pistons are usually made of cast iron, although in some designs makers prefer to fit a separate wrought steel top in order to avoid any tendency to crack. Trunk pistons are required not only to keep the cylinder gas-tight, but must be designed to act as guides and to take the thrust due to the obliquity of the connecting rods, and for this reason the practicable limit of size for this type is about 22 in. diam. The piston illustrated in Fig. 10 is suitable for a cylinder up to about 15 in. diam., which is about the maximum size of non-cooled piston which can be fitted. It is cast in one piece. Through the two bosses in the walls a gudgeon pin of case-hardened steel is fitted, which supports the eye of the connecting rod, locking pins being arranged to prevent the gudgeon pin turning. The crown is concave and very thick. It is not practicable to fit efficient guards and savealls to prevent the leakage of the cooling medium where it is necessary to cool trunk pistons, and accordingly oil is sometimes used in order to avoid contamination of the lubricating oil in the crankcase. The question of clearance in piston diameters varies according to the different makers and the particular purpose for which the engines are required. A good average for the 15-in. diam. trunk piston shown would be from about ·05 in. at the top to about ·005 in. at the bottom. A considerable contrast is offered in the design of the two-stroke and four-stroke crosshead types of piston, as shown in Figs. 11 and 12. The four-stroke piston is of comparatively short construction, the piston rod being bolted direct to the underside of the piston. The maximum size of uncooled piston is in the neighbourhood of 20 in. diam., the usual method of cooling adopted being by means of salt water, although in some cases fresh water or oil is used; but these are avoided as far as practicable in the ordinary mercantile design on account of the additional expense and complication involved, without any appreciable advantage for this particular service. For salt-water cooling, which is effected through telescopic pipes or through the piston rod by means of walking pipes from the crosshead, care must be taken to fit efficient guards and savealls to prevent leakage contaminating the lubricating oil. In the two-stroke engine an extension of some considerable length, varying directly with the length of the stroke of the engine, is required to prevent the exhaust and scavenge ports being uncovered when the piston is on the top centre. This extension is of very light construction and is made separately from the piston head, being bolted to same as shown in Fig. 11.

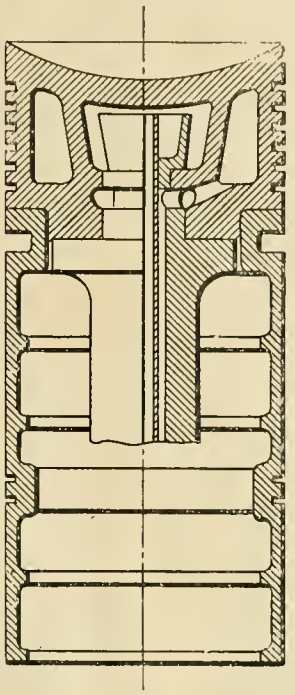


Fig. 11.

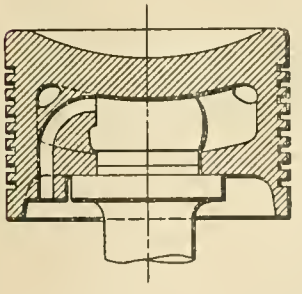


Fig. 12.

(*To be continued.*)

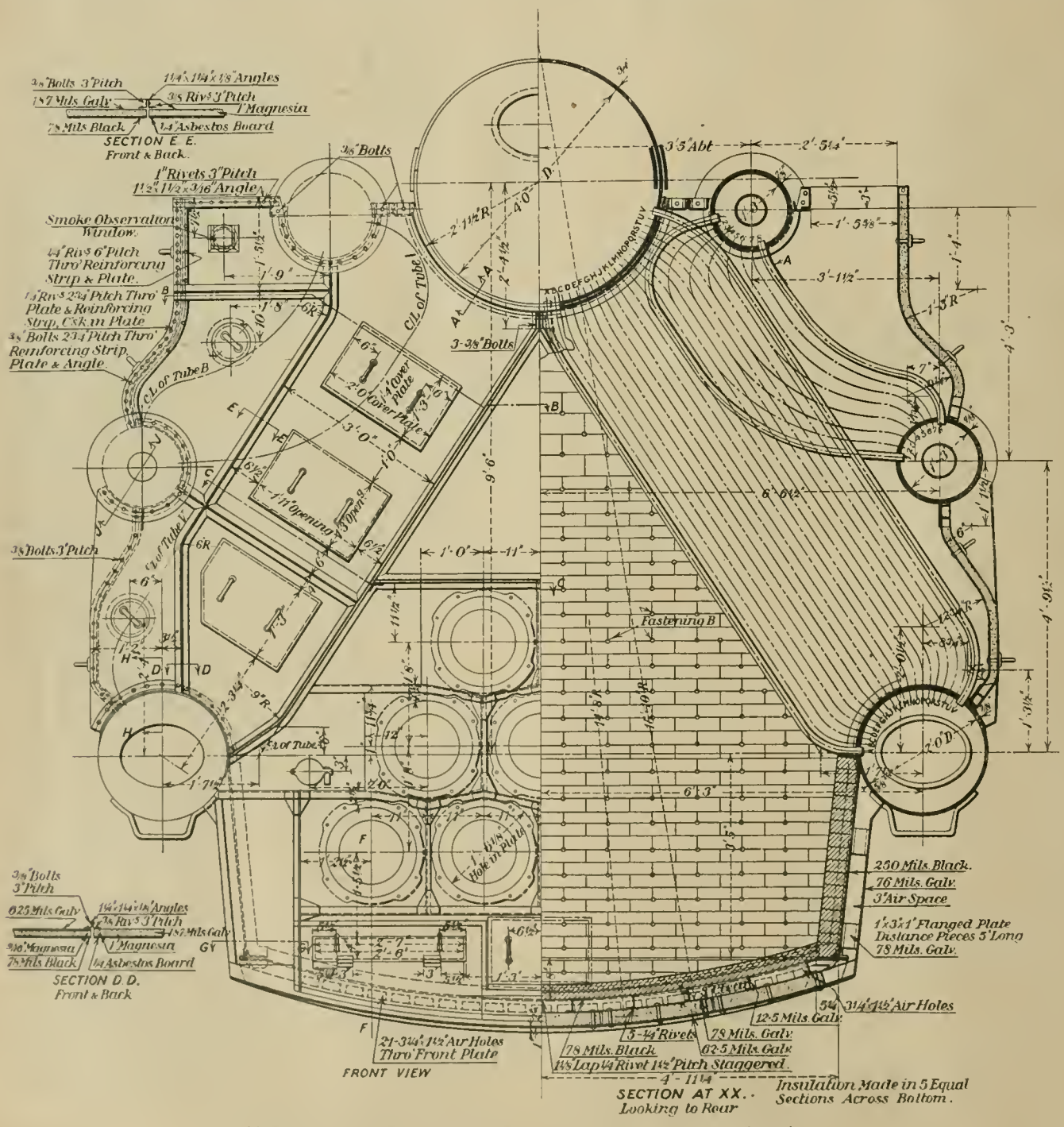
A NEW AMERICAN WATER-TUBE BOILER FOR CAPITAL SHIPS.*

Some Features of an Experimental Boiler Designed by Rear-Admiral Dyson, U.S.N.

In August, 1919, the Bureau of Engineering submitted to the Navy Department the plans for a boiler which had been designed by Rear-Admiral C. W. Dyson, U.S.N. The Bureau stated that it believed that this boiler would prove a particularly satisfactory steam generator for capital ships, and recommended that, from the plans submitted, one boiler be constructed for experimental purposes. The Navy Department authorised the construction of such a boiler, and awarded the contract for it to the Newport News Shipbuilding and Dry Dock Company.

The boiler was duly constructed in exact accordance with the original plans, and, in January, 1921, was delivered to the Philadelphia Navy Yard where it was set up at the Fuel

* Abstract of a Paper read by Lieut.-Commander H. G. Cooper, U.S.N., M.S., before the American Society of Naval Engineers, on "The Dyson Boiler," and published in the Journal of that Society.



The Dyson Water-Tube Boiler.—Front and Sectional Elevations.

Oil Testing Plant. After certain preliminary tests had been run to ascertain that the boiler was in proper condition, a Board was appointed to conduct official tests, and to report on the results. This article is based on the results of these tests as embodied in the official report of the Board.

Description of the Boiler.

The boiler was designed to meet the requirements for a steam generator for high-powered vessels of the Navy, these requirements being :—

1. High efficiency. The specifications for this class of boiler require that, when burning oil at the rates of 0·25, 0·5, 0·75 and 1 lb. of oil per square foot of heating surface per hour on the basis of oil having 19,500 B.Th.U. per pound, the evaporative efficiencies from and at 212° Fahr. shall be not less than 16·2, 15·75, 15·1 and 14·5 lb. of water per hour, respectively, per pound of oil.

2. Great heating surface compared to the weight and volume of the boiler.

3. Ability to stand forcing to the extent of at least 1½ lb. of oil per square foot of heating surface.

4. Furnace conditions that will permit smokeless operation at high steaming rates, and that will meet the specified requirements that "the maximum rate of combustion shall not exceed 10·8 lb. of oil per cubic foot of furnace volume per hour."

5. Superheaters that will provide a reasonably high degree of superheat, and through which the steam velocity and the pressure drop must be low, and which will meet the requirements of the specifications, as follows :—"The superheaters shall be so located as to permit of easy access and removal for examination, renewal, or repairs. The superheating tubes shall be so located among the generating tubes that the superheater tubes shall in no place be closer to the furnace than one-half the thickness of the generator tube nest, and so arranged that the entire products of combustion must pass across the superheating surface."

6. The absence of plate gas baffles, as these are prohibited by the specifications.

The boiler is of the Express type, and consists of one upper or steam drum, connected by two nests of tubes to two lower, or water drums. These tubes are straight except at the ends where they are bent to enter the drums normally. The two inner rows of tubes of each nest are 1⅝ in. in external diameter by 120 mils. thick ; the remaining tubes are 1 in. in external diameter by 109 mils. thick. In the outer half of each nest of tubes every third row of tubes in the direction of the axis of the drums is omitted to provide a space to be occupied by the superheater tubes. On the uptake sides of the generating tubes are located the two superheating units, one unit on each side, each unit consisting of two 15-in. drums connected by curved tubes 1 in. in external diameter by 109 mils. thick. The shape of the superheater tubes is such that when the superheaters are in place the superheater tubes occupy the spaces between the outer generating tubes in such a manner that the entire products of combustion must pass across the superheating surface. As originally designed, the only gas baffling consisted of a baffle wall about 15 in. wide on each superheating unit, the upper edge of the wall touching the upper superheater drum and resting on the outer row of superheater tubes. Retarders are installed in the outer three rows of tubes of each superheating unit. An idea of the appearance of the boiler can be obtained from Fig. 1.

The principal dimensions of the boiler are :—

Generating surface	6,170 sq. ft.
Superheating surface	1,016 sq. ft.
Total heating surface	7,186 sq. ft.
Working steam pressure	280 lb.
Furnace volume	654 cubic ft.

Estimated superheat at 1 lb. oil per square foot of water heating surface 60° to 80° Fahr.

Generating tubes, 1⅝ in. outside diameter by 120 mils. thick, approximate length 9 ft. 3 in., number 174.

Generating tubes, 1 in. outside diameter by 109 mils. thick, approximate mean length 8 ft. 6 in., number 2,500.

Superheating tubes, 1 in. outside diameter by 109 mils. thick, maximum length 7 ft. 4⅛ in., minimum length 4 ft. 8⅝ in., number 780.

Steam drum, 48 in. inside diameter, 12 ft. 1¼ in. long, number 1.

Water drum, 15 in. inside diameter, 11 ft. 11½ in. long, number 2.

Superheater drums, 15 in. inside diameter, 11 ft. 9¾ in. long, number 4.

Object of the Tests.

1. To ascertain, at various rates of combustion, the evaporative efficiency of the boiler and furnace as designed.

2. To determine the value of this boiler as compared with other boilers of the same type, as a steam generator for battleships, battle cruisers and scout cruisers.

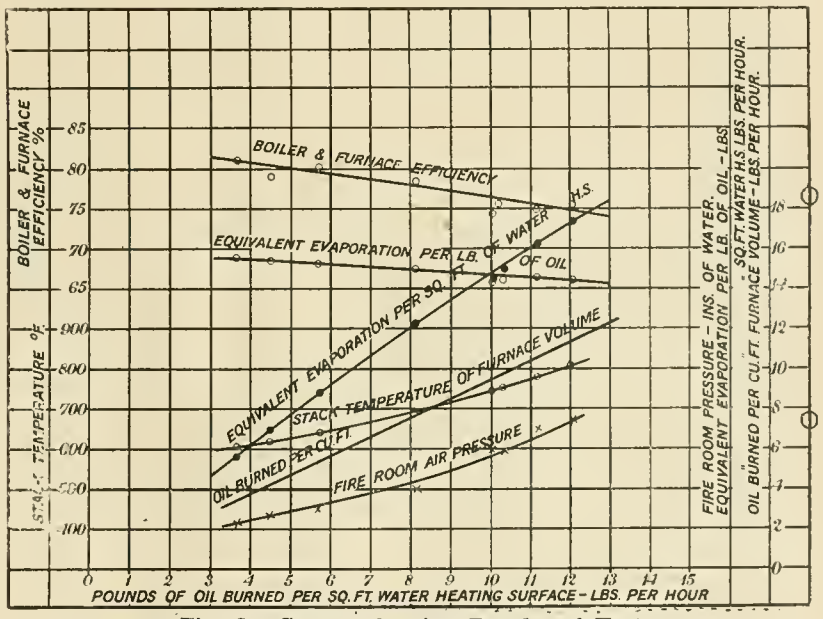

BOILER & FURNACE EFFICIENCY %
STACK TEMPERATURE °F
BOILER & FURNACE EFFICIENCY
EQUIVALENT EVAPORATION PER LB. OF WATER
H.S.
OF OIL
EQUIVALENT EVAPORATION PER SQ. FT.
STACK TEMPERATURE
OF FURNACE VOLUME
OIL BURNED PER CU. FT.
FIRE ROOM AIR PRESSURE
FIRE ROOM PRESSURE – INS. OF WATER.
EQUIVALENT EVAPORATION PER LB. OF OIL – LBS.
SQ. FT. WATER H.S. LBS. PER HOUR.
OIL BURNED PER CU. FT. FURNACE VOLUME – LBS. PER HOUR.
POUNDS OF OIL BURNED PER SQ. FT. WATER HEATING SURFACE – LBS. PER HOUR

Fig. 2.—Curves showing Results of Tests.

3. To determine, as far as possible, alterations in design and construction that will improve the efficiency of the boiler and its fitness for naval use.

General Description of Tests.

All tests were conducted with the boiler equipped with nine Bureau of Engineering Standard natural-forced draught air registers and Bureau of Engineering Standard fuel-oil atomisers. Fig. 1 shows the arrangement of the registers in the boiler front. The first series of tests (Nos. 38-1 to 38-5) were made with the boiler arranged in every way exactly as designed. The remaining tests were made with various arrangements of gas baffling. The size and position of the holes in the distributor pipes in the lower superheater drums were changed between tests as noted below. After test No. 38-21 and before test No. 38-22, moulded refractory furnace opening rings were substituted for the plastic clay rings used in the preceding tests. No other changes than these were made to the boiler during the course of the tests.

The official tests were started on March 1, 1921, and continued thereafter until completion.

Results of the Test.

The summary sheet (pages 154–55) and the curves plotted therefrom, Fig. 2, show the results of the tests Nos. 38-17 to 38-24.

The first series of tests, Nos. 38-1 to 38-5, were conducted

as previously stated, with the boilers exactly as originally designed. The following is a partial summary of the results :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–1	2	4	·250
38–2	2	3	·504
38–3	3	7	·751
38–4	3	9	·999
38–5	2	9	1·249

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–1	2·362	15·625	80·51	546	30·3
38–2	4·750	14·940	77·03	626	44·7
38–3	7·081	14·336	74·62	741	66·8
38–4	9·420	13·638	69·88	787	80·4
38–5	11·779	13·542	69·27	824	80·0

During this series of tests the furnace conditions, at all rates, were very bad. It was apparent that the gases had a short circuit to the uptake through the lower part of each nest of tubes. The incandescent gases did not reach the rear of the furnace, and it could be seen with the eye that nearly all the gases entered the nests of tubes near the lower drums. Also, at all rates, there was a heavy deposit of carbon in the form of a ridge about 10 in. wide, which formed about the middle of the length of the furnace on the furnace floor and extended up each side of the furnace for about half the length of the inner rows of tubes. From time to time the carbon deposited on the tubes would break up and fall to the furnace floor in large solid lumps. The deposits, while forming on the tubes, had somewhat the appearance of stalactites. No other carbon was deposited than this ridge which formed about the middle of the length of the furnace. At the end of five or six hours of steaming this ridge along the floor of the furnace would be about 8 in. in height by 10 in. wide. It was plainly evident that the short circuit path of the gases must be closed by some form of baffling, and it was believed that baffling would, to some extent, reduce the carbon deposits. However, it appeared that the carbon deposits were the results of the low grade of fuel which was being burned, and of the proximity of the burners to the furnace floor and walls which permitted the unburned gases to come in contact with these cold surfaces.

Before the next series of tests were conducted, lane baffles, consisting of U-shaped plates, were placed in the outer, lower parts of the nests of tubes in the lanes which, in the upper parts of the nests, are occupied by the superheater tubes. These lane baffles have the effect, not of completely closing the path of the gases through them, but of so impeding their progress that the same resistance is offered in all parts of the nests of tubes, the effect being the same as though the superheater tubes extended the whole length of the generating tubes. Plate baffles were installed to close the passage between the lower superheater drums and the generating tubes. It was predicted that the results of this baffling would be to reduce the stack temperatures, reduce the superheat, increase the evaporation, and reduce the amount of carbon deposited. The pressure drop from steam drum to steam line was rather high, and, to improve this, before the next series of tests the holes in the distributor pipes in the lower superheater drums were enlarged from $\frac{1}{4}$ in. to $\frac{5}{8}$ in., and the pipes were rotated 90 deg. so that the holes faced the inner walls of the drums instead of the lower walls. The following is a partial summary of the results of the tests with this arrangement :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–6	3	5	·505
38–7	2	9	1·004
38–8	2	4	·464

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–6	4·766	15·028	77·38	594	43·8
38–7	9·474	14·103	72·46	696	65·1
38–8	4·374	14·880	76·78	572	31·5

As predicted, the stack temperatures during these tests were reduced to a satisfactory point, the superheat fell off materially, and the efficiency increased, but to a less degree than was expected. It was apparent after these three tests that further changes in the gas baffling would have to be made, so no further tests were run with this arrangement. During these tests the furnace conditions were much improved over what they were during the first series, but the carbon deposit, although slightly less than previously, was still very bad. It was believed that this condition was due to the quality of the oil being burned. The inferiority and unsuitableness of the oil was evidenced by the fact that sparks of incandescent solids could be observed impinging on the rear wall of the furnace.

Before the next series of tests the baffling was again altered. The plate baffles between the lower superheat drums and the generating tubes were removed completely, and the upper part of the lane baffles were removed. It was expected that this would improve the superheat without lowering the efficiency, and at the same time keep the stack temperatures reasonably low. These tests were conducted with this arrangement, with the following results :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–9	$2\frac{1}{2}$	5	·504
38–10	2	5	·507
38–11	2	9	·898

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–9	4·754	14·844	75·89	633	39·4
38–10	4·770	14·688	74·99	670	48·8
38–11	8·470	13·172	67·24	775	87·0

These tests were conducted keeping the oil temperature constant at 185 to 190 deg., and the pressure constant at 165 lb., varying the steaming rate by varying the number of burners, and not by varying the quantity of oil per burner. The results were disappointing and the tests were discontinued after the third. The superheat was abnormally high, the stack temperatures were high, and the evaporation was very

low. No improvement in the pressure drop was observed as a result of the alteration to the distribution pipes in the lower superheater drums. The weather conditions during the test were very unfavourable. A pouring rain was falling during most of the time. The carbon deposit was substantially the same as in the previous test.

Before the next series of tests, the baffling was again altered. The plate baffles between the lower superheater drums and the generating tubes were replaced, except that a gas passage about 2 in. wide was left adjacent to the drums. The lane baffles were arranged as during tests Nos. 38-6 to 38-8. The holes in the distributor pipes in the lower superheater drums were again enlarged, this time to $\frac{9}{16}$ in. In order to determine the cause of the heavy carbon deposits, it was decided that, before conducting any further tests, a better grade of oil should be obtained. Accordingly a quantity of special oil was purchased. This oil, as the analysis shows, was particularly good. The following results were obtained :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–12	3	5	·503
38–13	2	9	1·005
38–14	3	9	1·385
38–15	2	4	·250
38–16	1½	7	·748
38–17	2	9	1·006

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–12	4·740	15·456	76·84	647	47·3
38–13	9·483	14·633	72·61	813	78·6
38–14	13·051	13·876	69·03	874	83·4
38–15	2·354	15·439	76·79	535	24·4
38–16	7·053	15·308	76·20	712	54·7
38–17	9·487	14·372	74·64	740	66·1

These results were considered quite satisfactory as regards efficiency, superheat and stack temperatures, and it was decided that the arrangement of the baffling was the best that could be made. As a result of the better quality of oil, the furnace conditions were greatly improved, and the carbon deposit was very materially reduced. The carbon, however, was still quite bad, and it was decided that this was due to the boiler front and that the condition could be corrected only by installing a different front, with some other register and atomiser. The weather conditions during the above tests were not very satisfactory, and therefore it was decided to conduct additional ones for the purpose of obtaining more nearly representative data, and to observe the effect of various register openings and oil pressures. No change was observed in the pressure drop from drum to line.

The following results were obtained on the next series of tests :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–18	2	4	·451
38–19	2	5	·564
38–20	2	7	·808
38–21	3	9	1·030

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–18	4·251	15·444	79·20	629	32·3
38–19	5·319	15·356	80·29	641	41·3
38–20	7·625	15·109	78·67	685	48·3
38–21	9·714	14·515	75·62	748	64·5

These results were considered satisfactory and representative of the boiler. The furnace conditions when using five or more burners were very good. The furnace conditions were best when the registers were slightly closed and the air pressure sufficiently high to give a velocity through the registers such that the flame would be projected well toward the rear of the furnace. The furnace is so deep that unless a high air velocity through the registers is used, the distribution of gases in the rear of the furnace is bad.

To obtain points at very high and very low rates of combustion, one more series of tests were conducted with the following results :—

Test No.	Duration.	Burners.	Oil per square feet H.S. per hour.
	Hours.	No.	lb.
38–22	2	9	1·113
38–23	2	9	1·201
38–24	2	4	·370

Test No.	Oil per cubic feet F.V. per hour.	Equal Evaporation.	Efficiency.	Stack Temperature.	Superheat.
	lb.				
38–22	10·500	14·566	75·15	777	69·0
38–23	11·328	14·403	75·19	808	69·0
38–24	3·485	15·513	80·88	505	28·7

The weather conditions while these tests were in progress were favourable. The data is believed to be reliable and representative. For the two tests at high rates, Nos. 38-22 and 38-23, the registers were partially closed and high air velocity through the registers was therefore necessary. This resulted in a very good furnace, and the carbon deposit was greatly reduced.

During tests Nos. 38-19, 20, 23 and 24, thermocouples were installed in the left nest of tubes, and from the temperatures thus obtained curves of temperature gradient were plotted.

The effect of weather conditions on the performance of the boiler was forcibly brought out. When it was raining, foggy or misty, and therefore when the air contained much unevaporated moisture, the efficiency of the boiler fell off to a marked degree.

Conclusions.

These tests indicate that this boiler will prove a highly satisfactory steam generator for capital ships. It meets all the specified requirements for such a boiler, and shows a somewhat better evaporative efficiency than other boilers of its class which have been tested. It is believed that with a different boiler front, using a smaller number of larger registers and burners, improved operating conditions, especially as regards carbon deposits, will be obtained.

A notable designer of steam ferries has passed away by the death, at the age of 74, of Mr. Charles Henry Tate, head of the firm of C. H. Tate & Sons, naval architects and engineers, Newcastle.

Data taken during Tests on Dyson Experimental Boiler. (*See pages* 150-53).

Water heating surface, 6,170 sq. ft.
Superheating surface, 1,016 sq. ft.
Total heating surface, 7,186 sq. ft.
Furnace volume, 654 cubic ft.

Evaporative Test on Dyson Experimental Battleship Boiler Equipped with Bu. Std. Natural Forced Draught Air Registers and Bu. Std. Fuel Oil Atomisers.

Number of tubes, 174—2,500—780 Superheater.
Size of tubes, 1⅜ in. O.D.—1 in. O.D.—1 in. O.D.
Diameter of steam drum, 48 in. I.D.
Working pressure, 280 lb. per sq. inch gauge.

1. Test number	38–17	38–18	38–19	38–20	38–21	38–22	38–23	38–24
2. Date	April 9, 1921	April 25, 1921	April 26, 1921	April 26, 1921	April 27, 1921	May 10, 1921	May 16, 1921	May 17, 1921
3. Barometer (in. of mercury)	29·892	30·175	30·180	30·161	30·169	29·992	30·220	30·250
4. Duration of test	2 hours	2 hours	2 hours	2 hours	3 hours	2 hours	2 hours	2 hours
5A. Number of burners used	9	4	5	7	9	9	9	4
5B. Size of atomisers	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 3/64 – 7/64	1/16 × 1/16 – 3/32
5C. Arrangement of burners used	All	6–7–8–9	6–7–8–9	3-4-5 6–7–8–9	All	All	All	6–7–8–9
6A. Type of air registers used	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.	Bu. Std. N.F.D.
6B. Aggregate opening of air registers (sq. in.)	590	294	330	461	557	432	432	248
Steam Observations.								
7. Steam pressure on drum (lbs. per sq. in. gauge)	275·5	273·5	272·5	273·5	274·1	274·5	273·5	273·2
8. Steam pressure below boiler stop (lbs. per sq. in gauge)	252·8	267·9	264·5	265·3	249·5	242·5	237·1	269·3
9. Superheater temperature (° Fahr.)	473·3	444·4	452·4	456·4	470·6	472·6	470·8	441·3
10. Calorimeter temperature (lower thermometer) (°Fahr.)	303·1	310·0	311·5	311·5	310·0	310·0	310·0	306·1
11. Calorimeter (inlet steam pressure) (lbs. per sq. in gauge)	261·5	271·0	268	263·5	259·1	257·0	254·0	271·2
12. Feed-water temperature at boiler (° Fahr.)	202·9	202·9	199·7	201·4	200·6	201·3	200·2	199·1
13. Water actually evaporated (lbs. per hour)	80,444	39,439	48,653	68,508	83,083	90,032	96,005	32,431
Fuel Observations.								
14. Oil burned (lbs. per hour)	6,025	2,780·5	3,478·5	4,987	6,353	6,867	7,409	2,279·5
15. Oil pressure at burners (lbs. per sq. in. gauge)	222·6	227·3	225·2	223·6	224·4	195·0	223·7	148·3
16. Oil temperature at burners (° Fahr.)	192·3	196·1	198·7	200·5	198·5	200·1	185·8	183·0
Air Observations.								
17. Dry bulb temperature (° Fahr.)	85·7	95·1	93·9	97·7	89·1	95·4	82·0	94·2
18. Wet bulb temperature (° Fahr.)	72·0	71·0	71·8	70·0	70·7	71·6	63·7	69·6
19. Fireroom temperature (° Fahr.)	91·3	100·0	100·4	106·4	93·0	99·0	88·4	98·9
20A. Stack temperature (° Fahr.)	740	629	641	685	748	777	808	605
20B. Furnace temperature (by optical pyrometer) (° Fahr.)	2,693	2,645	2,683	2,856	2,722	2,760	2,906	2,441
21. Fireroom pressure (in. of water)	5·834	2·610	3·032	3·976	5·824	6·951	7·413	2·370
22. Air pressure in furnace (in. of water)	+1·237	+·101	+·175	+·497	+1·212	+1·403	+1·539	+·066
23. Air pressure at base of stack (in. of water)	+·200	–·067	–·063	–·001	+·208	+·256	+·297	–·063
24. Smoke by Ringelmann scale	0—2	0	0—2	1—2	1—2	1	1	0
Flue Gas Analysis.								
24½. Sampling tube numbers	2*	* Right Uptake.	* Left Uptake.	2*	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*	1	2	3*
25. Carbon dioxide (per cent.)	12·73	12·87	11·73	14·02	13·90	13·83	13·77	13·80	13·92	13·70	12·87	13·27	12·17	11·00	13·53	13·47	10·30	13·40	14·10	11·30	11·10	11·50
26. Oxygen (per cent.)	3·65	3·76	4·70	2·02	2·16	2·30	2·36	2·30	2·28	2·55	3·53	3·02	4·40	6·00	2·64	2·70	6·90	2·93	1·87	5·50	5·70	5·25
27. Carbon monoxide (per cent.)	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·03	·10	·00	·00	·00
28. Nitrogen by difference (per cent.)	83·62	83·87	83·57	83·96	83·94	83·87	83·87	83·90	83·80	83·75	83·60	83·71	83·43	83·00	83·83	83·83	82·80	83·64	83·93	83·20	83·20	83·25
Ultimate Analysis and Physical Tests of Fuel.								
29. Carbon (per cent.)	85·05	83·86	84·35	84·14	84·20	84·18	84·26	84·29
30. Hydrogen (per cent.)	10·83	11·78	10·98	11·17	11·13	11·17	11·02	11·06
31. Sulphur (per cent.)	3·52	3·30	3·52	3·63	3·51	3·54	3·59	3·69
32. Nitrogen (per cent.)	·20	·30	·23	·23	·23	·23	·23	·23
33. Oxygen and undetermined (per cent.)	·40	·76	·02	·83	·93	·88	·90	·73
34. Gravity (Baumé)	17·36	19·8	17·6	18·0	18·0	20·4	19·95	20·0
35. Gravity (specific)	·9508	·9352	·9498	·9464	·9465	·9316	·9343	·9340
36. Flash point (° Fahr.)	200	200	205	185	185	195	205	200
37A. Viscosity temperature (° Fahr.)	192·5	194	199	199	199	200	186	183
37B. Viscosity (Engler)	5·01	2·29	2·30	2·19	2·19	1·73	2·19	2·46
38. Water and sediment (per cent.)	·4 sed.	·4 sed.	·7 sed.	·6 sed.	·6 sed.	·3 sed.	·4 sed.	·4 sed.
39. Calorific value (B.Th.U per lb.)	18,685	18,924	18,559	18,638	18,625	18,808	18,589	18,614
Steam Results.								
40. Superheat (° Fahr.)	66·1	32·3	41·3	48·3	64·5	69·0	69·0	28·7
41. Quality of steam leaving drum (per cent.)	98·79	99·10	99·20	99·24	99·18	99·19	99·21	98·90
42. Factor of evaporation	1·1086	1·0888	1·0979	1·0999	1·1099	1·1110	1·1115	1·0904
43. Actual evaporation per lb. of fuel (lbs.)	12·964	14·184	13·987	13·737	13·078	13·111	12·958	14·227
44. Equivalent evaporation per lb. of fuel (lbs.)	14·372	15·444	15·356	15·109	14·515	14·566	14·403	15·513
45. Actual evaporation per sq. ft. of water H.S. (lbs. per hour)	13·038	6·392	7·885	11·103	13·465	14·593	15·560	5·256
46. Equivalent evaporation per sq. ft. of water H.S (lbs. per hour)	14·454	6·960	8·657	12·212	14·945	16·213	17·295	5·731
47. Per cent. of total heat transfer taking place in superheaters	4·98	2·96	3·40	3·73	4·59	4·75	4·69	2·90

* Readings used in calculations.

Data taken during Tests on Dyson Experimental Boiler—*continued.*

Oil Results.								
8. Oil burned per sq. ft. of water H.S. (lbs. per hour)	1·096	·451	·564	·808	1·030	1·113	1·201	·370
9. Oil burned per cubic ft. of furnace volume (lbs. per hour)	9·487	4·251	5·319	7·625	9·714	10·500	11·328	·485
0. Oil burned per burner per hour (lbs.)	689·4	695·1	869·6	712·7	705·9	763·0	823·2	569·9
Air Results.								
1. Relative humidity (per cent.)	50·4	29·1	32·4	23·0	39·0	29·8	34·3	28·1
2. Dew point (° Fahr.)	65·1	57·7	60·7	53·7	61·2	58·9	50·6	55·9
3A. Moisture (lbs. per cubic ft.)	·000980	·000766	·000848	·000669	·000862	·000798	·000622	·000722
3B. Vapour pressure (e) (in. of mercury)	·618	·477	·530	·412	·540	·497	·368	·446
4. Weight of dry air (lbs. per cubic ft.)	·071483	·070812	·070721	·070365	·072110	·071102	·073541	·071161
5. Weight of air at atmospheric conditions (lbs. per cubic ft.)	·072463	·071578	·071569	·071034	·072972	·071900	·074163	·071883
6. Air at atmospheric conditions theoretically required for combustion of 1 lb. of fuel (cubic ft.)	191·5	195·6	192·8	194·5	189·5	192·5	185·5	192·1
Results From Orsatt and Ultimate Analysis.								
7. Weight of dry gases per lb. of fuel (lbs.)	17·39	15·12	15·40	15·39	16·59	16·71	16·76	18·35
8. Weight of dry air per lb. of fuel (lbs.)	17·56	15·22	15·51	15·47	16·70	16·82	16·86	18·49
9. Excess air from Orsatt (per cent.)	22·77	10·2	11·6	12·2	20·1	21·0	21·8	31·9
10. Volume of air at atmospheric conditions, used per lb. of fuel (cubic ft.)	—	—	—	—	—	—	—	—
11. Volume of air at fireroom conditions used per lb. of fuel (cubic ft.)	245·7	214·9	219·3	219·9	231·6	236·6	229·3	259·8
12. Velocity of air through vanes of air registers (ft. per min.)	6,202	4,878	5,548	5,700	6,340	7,026	9,438	5,731
13. Per cent. excess air over theoretical amount required for complete combustion	28·3	9·9	13·7	13·1	22·2	22·9	23·6	35·2

Heat Balance.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.	B.Th.U.	per cent.
14. Heat absorbed by boiler	13,947	74·64	14,987	79·20	14,901	80·29	14,662	78·67	14,085	75·62	14,135	75·15	13,977	75·19	15.054	80·88
15. Loss by imperfect combustion	—	—	—	—	—	—	—	—	—	—	—	—	27	·15	—	—
16. Loss with dry chimney gases	2,707	14·49	1,920	10·15	1,998	10·77	2,137	11·47	2,608	14·00	2,715	14·44	2,895	15·57	2.229	11·98
17A. Loss with moisture from hydrogen in fuel	1,305	6·98	1,356	7·16	1,269	6·84	1,305	7·00	1,344	7·22	1,355	7·20	1,363	7·33	1,262	6·78
17B. Loss with moisture in fuel	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17C. Loss with moisture in air	73	·39	41	·22	47	·25	40	·21	61	·33	60	·32	48	·26	45	·24
18. Radiation and error	653	3·50	620	3·27	344	1·85	494	2·65	527	2·83	543	2·89	279	1·50	24	·12
19. Total	18,685	100·00	18,924	100·00	18,559	100·00	18,638	100·00	18,625	100·00	18,808	100·00	18,589	100·00	18,614	100·00
20. Boiler and furnace efficiency (per cent.)	74·64		79·20		80·29		78·67		75·62		75·15		75·19		80·88	

STANDARD RULES GOVERNING THE CONSTRUCTION OF WATER-TUBE BOILERS.

Part V of the "Standard Conditions for the Design and Construction of Marine Boilers and Shafting," prepared by the British Marine Engineering Design and Construction Committee, deals with tubulous or water-tube boilers. This Committee was appointed by such prominent technical institutions as the Naval Architects, Engineers & Shipbuilders in Scotland, North-East Coast Engineers and Shipbuilders and the Marine Engineers, and also by Lloyd's, British Corporation and the Bureau Veritas Classification Societies. The increasing adoption of water-tube boilers in the mercantile marine has called for some well-ordered system regulating and standardising the scantlings and tests of the various materials used in their construction. Formulæ have been put forward by the Committee fixing the minimum thicknesses of tubes, tube plates, headers and other flat heating surfaces and the boiler mountings in natural, forced draught and coal or oil-fired steamers. It is stipulated that the generating tubes connecting the drums or headers shall be set at an inclination of not less than 15 deg. to the horizontal, but where tubes are arranged in series forming a continuous run, as in the Belleville boiler, the inclination need not exceed 5 deg. When the steam drum is exposed to the impact of hot gases and is not protected by the tubes, a shield of good refractory material of low conductivity must be fitted, or alternatively at least 2·5 in. of water must be maintained in the drum so long as there is fire in the furnace. Where superheaters are fitted these must embody a safety valve at their delivery ends, and this valve shall be loaded to a pressure slightly less than that on the main boiler safety valves, so that the superheater valve may operate first and thus preserve a circulation through the superheater when the engines are stopped suddenly.

All tubes are required to be solid drawn from steel produced by an open-hearth process, acid or basic, having an ultimate tensile strength not in excess of 28 tons per sq. in. and with an elongation of not less than 25 per cent. Hydraulic tests equal to at least four times the working pressure of the boiler shall be imposed, and in no case must the test pressure be less than 1,000 lb. per sq. in., nor more than 1,500 lb. per sq. in. Tubes should be practically concentric throughout their length, and the minimum deviation allowed from the specified thickness is 5 per cent. under at the thinnest part and 10 per cent. excess at the thickest section. Repeated failures of the lower rows of tubes have been met with in practice, and to obviate this it is specified that the two lower row tubes next the fire shall be of a slightly heavier gauge, as arrived at by formula.

Combining as it does the highest technical and practical experience, the Committee has set forth definite recommendations which cannot be regarded as other than the most authoritative regulations which it is possible to prepare at the present time.

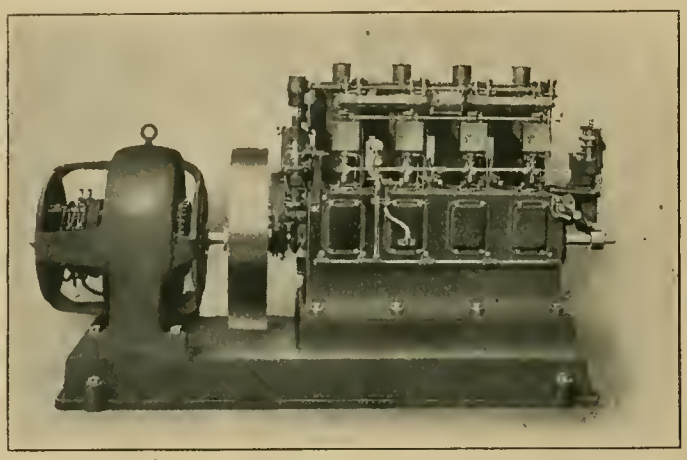
SOME LIGHTING ARRANGEMENTS ON THE "CONTE ROSSO."

55 h.p. Gardner Emergency Lighting Set and Callender Special Cables, as fitted in this new Twin-Screw Italian Liner.

On page 123 of the March issue we published some details of the machinery and electrical installations on the twin-screw Italian liner *Conte Rosso* which was built and engined by William Beardmore & Co. Ltd., at their Naval Construction Works, Dalmuir, to the order of Lloyd Sabaudo, of Genoa, for their passenger and cargo service between Italy and the Americas. The lighting on this vessel is carried out on the ring main system, and an emergency lighting set has been supplied consisting of a 55 h.p. Gardner paraffin engine, direct coupled to an Allen generator.

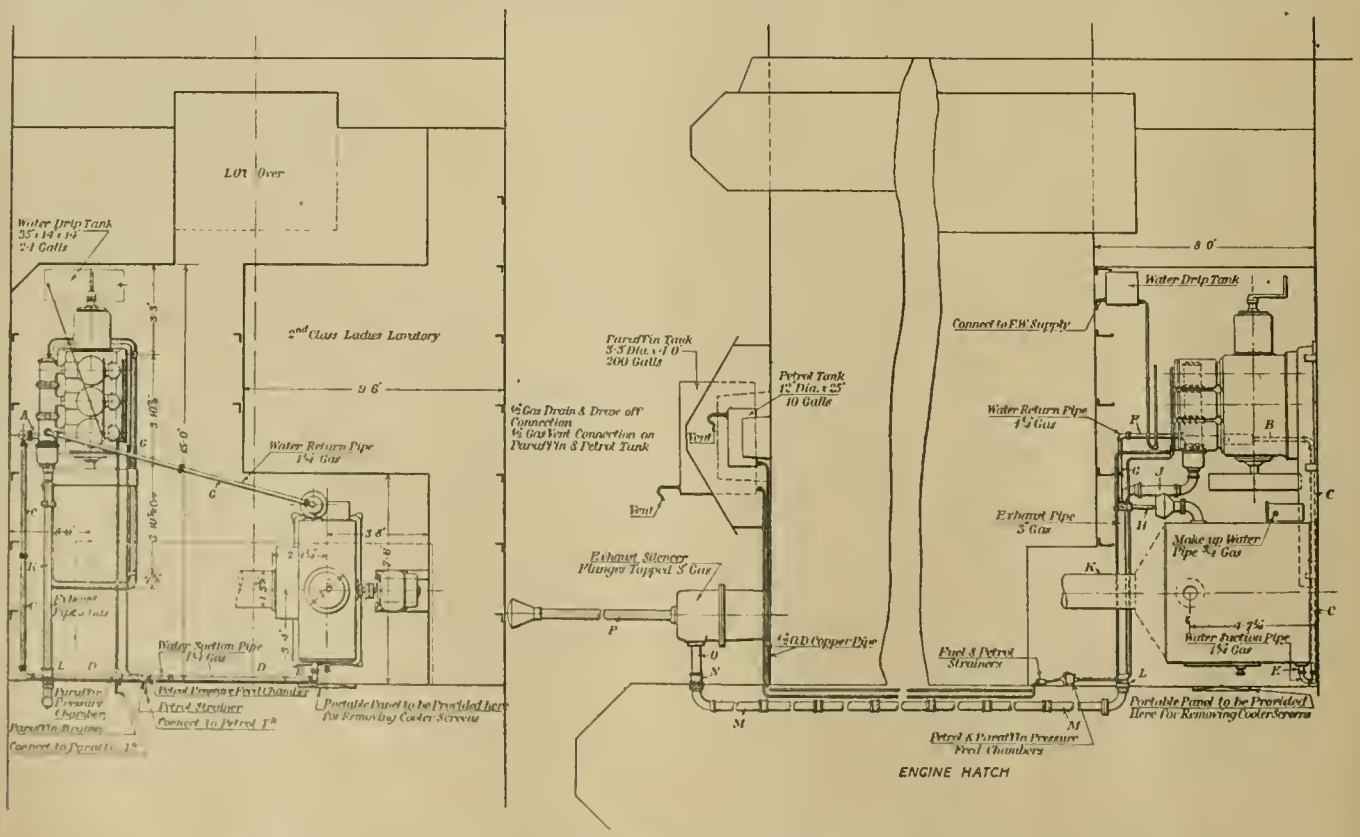
We reproduce herewith drawings showing this engine and electric generator mounted on a common bedplate, and also showing the general arrangement of the plant on board. There is also reproduced herewith a photograph from which the contour and general appearance of a similar fully assembled set will be readily apparent.

The set consists of one of the Gardner "M" type paraffin engines developing 55 b.h.p. at 500 r.p.m., and manufactured by Norris, Henty & Gardners Limited, Patricroft, Lancs. This engine is directly coupled to an Allen generator, carried on the common bedplate and giving an electrical output of 33 kw. A gravity system of fuel feed has been arranged, the fuel being supplied from a paraffin tank of 200 gallons capacity, or, alternatively, a petrol tank with a capacity of 10 gallons for starting purposes. The engine takes the fuel at a maximum pressure of 5 lb. per square inch, and as these tanks are situate 40 ft. above the engine room, giving a pressure of approximately 18 lb. per square inch, it was necessary to fit a reducing valve. The cooling arrangements consist of a water cooler and a motor-driven fan, as shown on the accompanying drawing.



Gardner Emergency Electric Lighting Set.

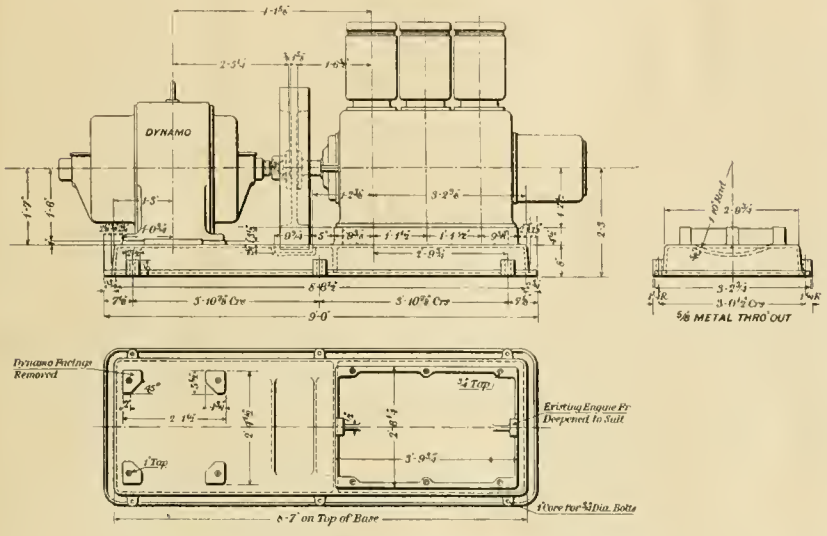
Exhaustive trials of the complete set were carried out on February 15, when the engine was run for a period of 32 hours under conditions of full load. The performance of the set is reported to have been completely satisfactory, and it is understood that the sister vessel, *Conte Verdi*, at present under



General Arrangement of Gardner Emergency Lighting Set on board "Conte Rosso."

construction, is being equipped with a similar emergency set.

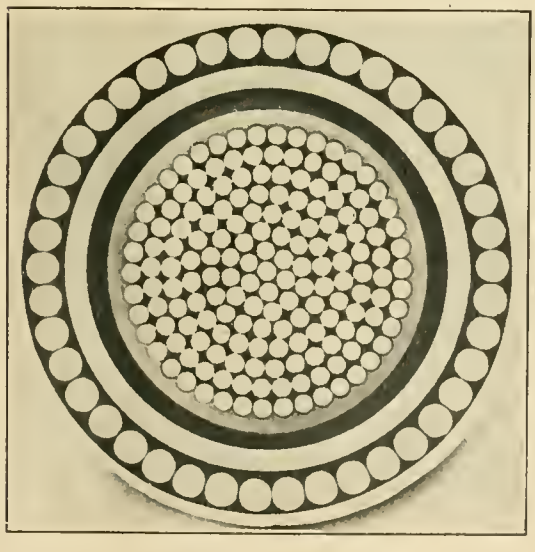
The electrical installation on this steamer is of special interest, inasmuch as it is believed to represent the first installation on a merchant vessel in which the Admiralty practice of fitting a ring main has been applied. This ring main has a sectional



55 h.p. Gardner Paraffin Engine direct coupled to Allen Generator.

area of 2 sq. in. of copper, and is stated to be the largest cable installed in a merchant ship. To the manufacturers of this cable, Callenders Cable & Construction Company Limited, Leigh, Lancs., we are indebted for the following particulars relating to the construction of the cable :—

		Diameter over
Strand	169/·124	1·860 in.
V.I.R.	·200 Wall	2·260 ,,
Tape	2 × ·010	2·300 ,,
Lead	·150	2·600 ,,
Tanned jute yarn	·100	2·800 ,,
G.I.W. armour ...	42/·192	3·184 ,,
Bitumen tape ...	·015	3·214 ,,
Hessian tape	·035	3·284 ,,
F.W.R. paint	—	3·300 ,,



Section of Special Callender Cable as fitted in "Conte Rosso."

CORROSION AND CRACKING OF CONDENSER TUBES.

Few subjects have more consistently engaged the attention of operating engineers ashore and afloat or have figured more prominently in the papers and discussions of technical institutions and research committees than the effective protection of condenser tubes against corrosion and the several other factors which contribute towards failure. At the annual general meeting of the Institute of Metals, held on March 8, two further papers on this somewhat complex and many-sided subject were read, as follows:—"Notes on the Corrosion and Protection of Condenser Tubes," by C. D. Bengough, M.A., D.Sc., and "Further Studies in Season-Cracking and its Protection—Condenser Tubes," by H. Moore, O.B.E., Ph.D., F.I.C., and S. Beckinsale, B.Sc.

As investigator to the Corrosion Research Committee, Dr. Bengough has carried out scientific investigations covering every aspect of the problem during a period of approximately 10 years, and definite conclusions have been put forward based on an extended experience of the practical working of condensers. As a strictly practical paper, taking the fullest account of the respective viewpoints of the manufacturer of the tubes, the maker of the condenser, and the operating engineer, this may rightly be said to be the most authoritative expression of opinion on the methods of protecting condenser tubes from corrosion that it is possible to prepare at the present time. While appreciating that the most fertile cause of failure of condenser tubes in service is corrosion, the authors of the latter paper point out that occasional failures occur, both in store and on service, by the development of cracks arising from internal stress, and this paper is a record of the work done in consequence of a suggestion made by the President, Engineer Vice-Admiral Sir George Goodwin, in the discussion on a paper presented to the Institute two years ago by the same authors.

The factors contributing to the failure of a condenser tube are so many and varied that it is rarely possible to point to any single factor as being the sole cause of actual perforation, and when such perforation has been observed it will more generally be found to have been the cumulative result of several different factors. Moreover, it is doubtful if similar conditions ever obtain in any two condensers, and while experiments carried out in any individual plant or ship may have been attended with marked success, such experiments cannot be applied in another case with any degree of hopefulness unless all the conditions are known.

New tubes have been found to be particularly susceptible to corrosive action, and the preparation of artificial scale prior to tubes being used has been attempted but with only partial success. The principal difficulty has been found to be the time factor as experience shows that to obtain a really resistant scale its deposition must be effected slowly. As a period of several months has been suggested, this method has certain commercial disadvantages, but the results obtained are such as to encourage the further study of this phase of the subject.

There are those who to-day advocate the lining of condenser tubes with metallic layers, and it is known that during the recent war, tubes lined with lead were used by the German fleet, with, it is understood, quite satisfactory results. For adequate protection the layer of lead should have a certain minimum thickness and here again a secondary difficulty arises, since very thin layers which appear continuous are liable to develop porous conditions.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Electric Welding.

Electric welding is undoubtedly one of the most economical processes at the disposal of the shipbuilder and ship repairer. Its application is by no means a new idea, and for at least 30 years resistance and arc welding have been more or less consistently and satisfactorily practised. With regard to the welding of cast iron and also to the elimination of riveted work in structures by the adoption of electrically welded joints, much experience and experiment is still required before these processes can be considered absolutely reliable. Research work on the subject is undoubtedly necessary, and a research station has been founded in Hamburg for this purpose. The author next refers briefly to the general theory of welding and the usual practical welding outfits. The electric heating of rivets is next mentioned, and also a recent American patent for electrically heating rivets and simultaneously closing them by hydraulic or pneumatic pressure. The various disadvantages of arc welding, both practical and physiological, are dealt with at length. In conclusion, the author states that one of the purposes of the research station should be the training of men to take up the trade of electric welding.—*O. Wundram, Werft, Reederei, Hafen*, February 22, 1922, p. 101 ; 3 pp.

Model Experiments for Motor Fishing Boat.

Similar experiments to those referred to in the February "Notes" have been carried out by Dr. Schaffran for the Pommern Werft of Swinemünde on a model of one of their motor fishing boats, which, although very similar in form, is slightly larger and fuller than the type previously dealt with. In the present case the dimensions are as follows :—Length overall, 36 ft. ; breadth, 11 ft. ; mean draught, 3·3 ft. ; displacement, 11·9 tons ; block coefficient, 0·344 ; 'midship section coefficient, 0·611 ; wetted surface, 353 sq. ft. As before, the aim of the research was to determine the most economical cruising and trawling speeds and the most suitable design of propeller. Experiments were carried out over a range of from two to six knots, both with and without propeller, the results being given in a series of diagrams. From these and photographs of wave formation the economic cruising speed was found to be six knots. In order to utilise as before a Callesen 15 b.h.p. crude-oil motor which developed its full power and had its lowest fuel consumption at 420 r.p.m., it was found that the best propeller was of a two-bladed type, 2·35 ft. diam., 2-ft. pitch, disc area ratio 0·28, having an efficiency of 59·8 per cent., and capable of driving the vessel at 6·55 knots. For the trawling condition, at a speed of 2·5 knots, the vessel could tow 218 kg. or 14·5 kg. per brake horse-power, provided that when the propeller was working at the designed revolutions of 420 its pitch could be mechanically reduced to 1·76 ft., thus producing a maximum attainable efficiency of 28·5 per cent. The article is well illustrated, and very complete information, embracing the actual lines of the vessel, also the full series of resistance results, is placed at the reader's disposal.—*Dr. K. Schaffran, Der Kleinschiffbau*, February 25, 1922, p. 53 ; 6 pp. ; 12 ff.

Kinematics of Machinery.

The kinematic analysis of machinery has in the past tended to be restricted to prime movers where the inertia of rotating and other parts is of fundamental importance in the design. The author considers that the design of machine tools has not received sufficient attention in this respect, and attempts to examine many of the motions in the more important German machine tools. The motions considered are classified as follows :—Uniform rotation, non-uniform rotation, oscillating rotational movement, oscillating straight-line movement, and motion along any determined path. The various methods of obtaining these motions and their velocities and accelerations are outlined. Amongst the machines considered are shaping machines with quick return stroke, and drilling machinery of various types. Various cam motions are investigated, and the general problem of reducing the idle stroke by various types of mechanism is very thoroughly dealt with. The treatment throughout, while very detailed, avoids complicated mathematics by the extensive use of graphical analysis.—*F. Wittenbauer, Z. d. V. d. I.*, January 14, 21, 1922, pp. 25, 60 ; 8 pp. ; 45 ff.

Economic Construction of Ships.

The above is the subject of a lecture recently given in Hamburg by Dr. Dahlmann. After discussing the present inflation of tonnage, the author stresses the necessity for improved methods of ship construction. Sheerless ships, straight frames, cruiser sterns, simplified forms, are not, according to the author, the desired improvements. Better attention is required on the part of the owner who should examine, through his own naval architect, the condition of his trade, and should then, through careful collaboration with the shipbuilder, be able to produce the most economical ship. In the structural design of the ship the present material economy of bridge structures should be sought after. This could be facilitated by a more scientific presentation of the practical findings of the classification societies. For instance, in the case of bulkheads it is suggested that only the loading conditions and permissible stress should be specified. The question of the double-bottom controversy is mentioned and the possible equivalent safety and greater strength of the single-bottom ship commented on. Better construction of superstructures is required, and the fitting of expansion joints should, according to the author, be done away with. Much has yet to be done in the design of the transverse structure of ships, and the influence of bulkheads and web frames should be allowed for in the determination of frame scantlings. The stability of ships is briefly touched upon, and the need is emphasised for the education of ships' officers in this branch of naval architecture. Finally, the actual details of construction are considered, principally amongst these being type of rivets and electric welding.—*Werft, Reederei, Hafen*, March 7, 1922, p. 130.

Resistance of River Craft.

This article forms a criticism of an earlier article on the same subject by J. Faust, published in the *Schiffbau*, October 20, 1920. The author points out some misconceptions on the part of Faust relating to the effect of stream gradient upon the speed of river craft, and also maintains that the work of previous authors which Faust had adversely criticised were both fundamentally sound and backed by experiment. The effect of stream gradient is shown to be analogous to that of a railroad gradient in the case of a locomotive. The author goes on to explain how a vessel is able to float down stream at a greater rate than the current itself. The kinetic energy of the vessel and of the current is, of course, produced by the stream gradient, but owing to the formation of eddies by the sediment and roughness of the stream bed only a portion of the current energy appears as a forward motion of the stream. The submerged portion of the ship displaces an amount of water equal to the ship's weight, and thus the submerged hull behaves as an equivalent mass of water which is only capable of forward motion and thus incapable of eddy formation. The velocity of the vessel will be thus greater than the stream, and will in fact reach a limiting speed whose value is limited by the increased resistance at this higher speed. The author, in the light of these considerations, deals with their application to the powering of river vessels. He shows that whilst the phenomenon has at least on one occasion been experimentally confirmed, yet it has apparently been generally ignored by firms undertaking the design and construction of river vessels.—*E. Beyerhaus, Schiffbau*, February 22, 1922, p. 64 ; 3 pp. ; 1 f.

Recording Instrument for Bridge to Engine-Room Signals.

A description is given of an instrument which has recently been fitted by the Compagnie Messageries Maritimes for registering the communications made from the bridge to the engine room during the trials of their ss. *Lotus*. The instrument permits of the registering of any order sent from the bridge to the engine room, the registering of the repetition of the order from the engine room and also the number of revolutions turned through by the shaft between the time of a given order and its repetition. The instrument will serve to eliminate the likelihood of controversy in case of collision and accidents, and is, of course, additional to the usual engine-room telegraphs and revolution-counters. It can be conveniently kept in the chart house, and measures 42 × 80 × 50 cm. Two distinct graphic records are made by it, one for the bridge signals and the other for the engine-room signals. Typical records are shown.

Each signal is indicated by a letter, and the number of revolutions given by the number of dots in the unit division representing one second. For ahead movement the dots are solid, and for astern annular. Apart from the obvious functions of the instrument it also serves to show if any derangement has taken place in the ordinary telegraphs.—*Bull. Tech. du Bureau Veritas*, February, 1922, p. 44 ; 1 p.

Uses for Broken Drills.

The considerable waste which takes place in shipbuilding and allied industries through the breaking, and hence the discarding, of drills may be greatly minimised by use of a device recently patented in Germany. This device enables almost all the originally useful length of the drill to be used again, and simply consists of a sleeve which is carefully cast on to the fractured drill. The problem in the casting was to find a suitable alloy, and after long research an alloy was obtained which melted readily and possessed the adequate strength and rigidity. Details are given of the fitting and preparation of the sleeve. The patent has been in successful and general use for over a year. In large works the license of the patent extends to the whole process of preparation and casting, but for the convenience of smaller firms a special company has been formed to undertake all necessary preparation. The adoption of the patent by shipyards, &c., is strongly recommended.—*A. Kummer, Schiffbau*, February 8-15, 1922, p. 573 ; 1 p. ; 2 ff.

Marine Paints and Compositions.

After a general introduction in which the various applications of paint in marine work are outlined, the author proceeds to consider in close detail the chemistry of the action of sea water upon steel structures. Sea water and its multitudinous impurities are first touched upon, such points as oxygen, nitrogen and carbon dioxide contents, salinity and temperature of various seas being carefully detailed. The history of marine compositions from the time of the Phœnicians until the present day is treated very completely. The various compositions invented during the last fifty years are discussed, and in many cases their actual constituents given. The phenomena of corrosion is next considered in its various aspects, and the respective parts played by the action of the air, carbon dioxide, rust itself, salts in solution, heterogeneity of the metal, impurities and voltaic action are treated very fully. The article is especially valuable not only for its intrinsic worth, but also for the large number of Continental references given on this important subject of corrosion.—*H. Rabaté, Bull. Tech. du Bureau Veritas*, February, 1922, pp. 29 ; 5½ pp. ; 1 ff.

Apparatus for Technical Education.

The Union of German Technical-Scientific Societies is devoting considerable attention to the improvement of technical education. Realising the important part played by illustrations, photographs, diagrams, &c., in technical education and also the considerable work involved in the preparation of such facilities, a central bureau has been established to undertake the necessary work. The author emphasises the necessity for co-operation, and shows by his own efforts what could be done. In the preparation of diagrams—which may be specially prepared or which may be culled from such multitudinous sources as trade catalogues, the technical press, &c.—it is essential to adapt the photograph to the subject in hand. For instance, illustrations are given of a turbo-dynamo which is surrounded by a mass of irrelevant shop environment. The photograph is then tinted, the important parts brought out and the irrelevant matter subdued, thus enormously increasing the value of the photograph as an educational instrument. At least a dozen similar examples are given. The case of line diagrams and the value of heavy and coloured lines is very clearly demonstrated. It is interesting to note that many of the diagrams are applicable over a range of subjects, and that the Dewey Classification is proposed to be used throughout. When such an undertaking is completed German technical education will undoubtedly be greatly assisted. At present the Central Bureau is a distinct organisation, but later on in the year it is to be taken over by the Vereine deutscher Ingenieure.—*Dr. O. Lasche, Zeitschrift des Vereines deutscher Ingenieure*, January 7, 1922, p. 1 ; 3 pp. ; 12 ff.

Boiler Efficiency and Irregular Steam Consumption.

In order to determine the difference in fuel consumption due to very irregular as opposed to the regular utilisation of steam, Professor Josse has carried out a series of trials on one of the laboratory boilers of the Charlottenburg Technical High School. The boiler, which is of the vertical tube type, has been recently built by Walther & Co., and has a heating surface of 2,470 sq. ft., a superheater of 980 sq. ft. and an air heater of 1,820 sq. ft. The experiments were carefully carried out and diagrams of the results of the respective conditions are given. When the amount of steam consumed was varied between the limits of 6,600 and 24,000 lb. per hour it was only possible to force the boiler to three-quarters of the normal load, and the steam pressure fell from 206 to 118 lb. per square inch. The flue gas temperature ranged between 200° and 240° C. and the CO_2 content between 3 and 10 per cent. The research showed clearly that these alterations could not be met by controlling the air to the furnace. In spite of the small amount of steam generated per hour (4·4 lb. per square foot) the safety valve blew off occasionally. The average efficiency only amounted to 77·5 per cent. For regular steam consumption (ranging from 19,000 to 21,000 lb. per hour) the boiler pressure was practically constant at 184 lb. per square inch, flue gas temperature, 220° to 230° C., and the CO_2 content 11 to 13 per cent. The boiler generated from 5·5 to 5·7 lb. of steam per square foot of heating surface per hour, and an average efficiency of 83 per cent. The research brings out the considerable influence of variable steam consumption upon boiler efficiency.—*Zeitschrift d. V. d. I.*, January 21, 1922, p. 62 ; ½ p. ; 1 f.

Economical Ships.

A ship is most economical, other things being equal, when her initial cost and subsequent upkeep are smallest. Economy is largely affected by the absolute length of the ship, the value of which, in the case of cargo ships of a given displacement, can be obtained so as to yield a minimum resistance. This minimum exists because with increasing length for a given speed the wave-making resistance decreases, whilst, on the other hand, the frictional resistance increases. The author intends to show that this point has been neglected and that many ships have been built of too great a length. The problem of the best prismatic coefficient and ratio of beam to draught is also considered. An analysis is first made of the relative values of displacement, wetted surface and length of ship. The case of a cylindrical vessel whose area per unit displacement is, of course, the smallest of all possible shapes, is first considered. The ratio of the wetted surface of a cylinder to the square root of the product of its displacement and length produces a number 2·507 (metric units), which is taken to represent the ideal case, and the ratio to this standard of the similar number derived from actual ships, measures the efficiency of their distribution of wetted surface. For instance, in warships with rounded bilge this efficiency is from 96 to 98 per cent. ; in cargo vessels with square bilge it is 92 to 95 per cent. In order to obtain the optimum value for the length prismatic coefficient and beam-draught ratio, Taylor's standard experiments are analysed. The form resistance in kilogrammes per ton divided by $\frac{V^2}{2gL}$ is plotted for each prismatic coefficient upon a base of length of corresponding model, the loci produced being sensibly straight lines, and hence are expressible in the form of a simple linear equation. This equation, after complicated mathematical manipulation and inclusion of the frictional term, is finally established. This resistance equation, as it is called, is then differentiated with respect to the length of the ship, and an expression (somewhat complicated) deduced for the optimum length for a given set of conditions. The resistance equation is further differentiated with respect to the prismatic coefficient and also the beam-draught ratio and equations are established for the optimum values of these respective functions *(to be continued)*.—*W. Schmidt, Zeitschrift d. V. d. I.*, March 11, 1922, p. 230 ; 4 pp. ; 22 ff.

The Experimental Determination of Propeller Thrust.

The knowledge of the thrust produced by the propeller in full-sized ships has been sought after ever since the introduction of the screw into marine propulsion. The contribution to this knowledge by means of model experiments, whilst considerable, is not yet beyond reproach owing to the difficulty in duplicating sea conditions in each particular case and the necessarily small scale of the experiments. The recent work of Dr. Bauer on screws up to 2 ft. 6 in. diam. is extending the experiment tank progress, and Dr. Bauer has also emphasised the utility of thrust indicators fitted to full-sized ships. Considerations of cost prevent the general adoption of these desirable extensions, and the author considers how the propeller thrust may be experimentally determined by means of other less expensive, although as is readily admitted, less accurate methods. The first of these consists in obtaining the deceleration of the ship from full speed to some lower speed, and then from the differential equation of motion, deducing the thrust as a function of the speed. This method is open to the important objection that the mass of

water moving along with the vessel is not known, and, moreover, the fact that the propeller does not rotate during the deceleration invalidates the accuracy of the thrust estimation. The second method consists in accelerating the vessel from rest, and from the usual observations the differential equation is formed, and from its solution the value of the thrust obtained; but in this case not only as a function of the speed of the ship but also of the revolutions of the propeller. This, whilst an improvement on the former method, inasmuch as the propeller is now in motion, is still approximate as the wake speed in this condition of acceleration is still different from that obtaining when the ship is moving uniformly. The third method is more accurate and consists, as in the second method, of first expressing the thrust as a function of n and v (*c.f.*, the thrust is expressed $T = An^2 - Bnv - Cv^2$). The ship is first moored to buoys as in the ordinary steaming trials; v is thus zero, and hence the best value of A can be obtained over a range of revolutions. Next the ship is run at a fixed ahead speed, and the revolutions at that speed varied by increasing the head resistance overcome by the propeller. This is done by towing a series of barges and measuring their resistance by a dynamometer. Thus at a given speed there are three unknowns, T, B and C, and if three different resistances are produced by varying the number of barges then three equations are available for the calculation of the three unknowns. An attempt is made to apply the theory to some work on tugs carried out and published by Dr. Schaffran, but owing to the incompleteness of the data the application is more illustrative than convincing.—*Professor Prôll, Werft, Reederei, Hafen*, February 22, 1922, p. 91; 4 pp.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.

We have received the following letter from Mr. G. H. Murray, Shipyard Manager and Director of Hawthorns & Co. Ltd., Leith:—

"53, Dudley Crescent, Leith,
"March 23, 1922.

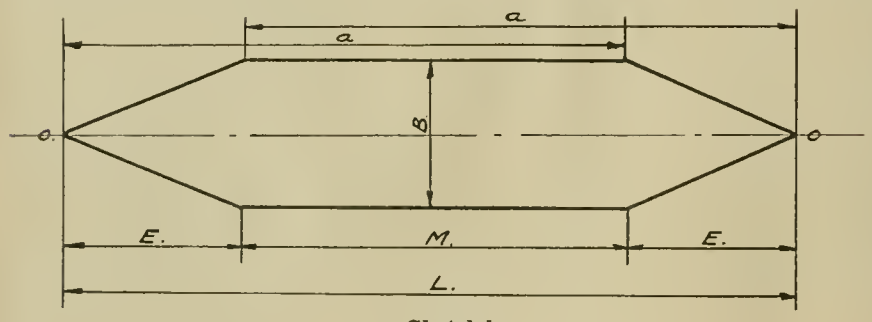
"To the Editor of The Marine Engineer and Naval Architect.

"In your issue of January, No. 532, Vol. XLV, there is an article by E. V. Telfer, B.Sc., on "The Transverse Metacentric Height of Ships,' in which is quoted my formula for inertia of waterlines, and which is designated 'Straight Line.'

"Perhaps it would interest your readers if I were to explain how that formula is derived, which I gave in a paper read by me before the Aberdeen Mechanical Society fourteen years ago.

"Suppose the waterline to be of straight lines as per sketch A:

"L = length of waterline.
"B = breadth of waterline.
"a = waterline coefficient.
"I_o = moment of inertia about 0·0.



Sketch A.

then

"I_o of middle part $M = \frac{M B^3}{12} = \frac{2 M B^3}{24}$.

"I_o of half one end part $E = \frac{E \times \frac{B}{4} \times (\frac{B}{2})^2}{6}$.

"I_o of both end parts $E = \frac{E B^3}{96} \times 4 = \frac{E B^3}{24}$.

"I_o of total waterline $= \frac{2 M B^3 + E B^3}{24}$

$= \frac{(2 M + E) B^3}{24}$

"Now $E = L (1 - a)$,

$M = L (2a - 1)$.

"$\therefore$ I_o of total waterline $= \frac{(3a - 1) L B^3}{24}$,

and $B M = \frac{I}{V} = \frac{(3a - 1) L \times B^3}{L \times B \times d \times b \times 24}$

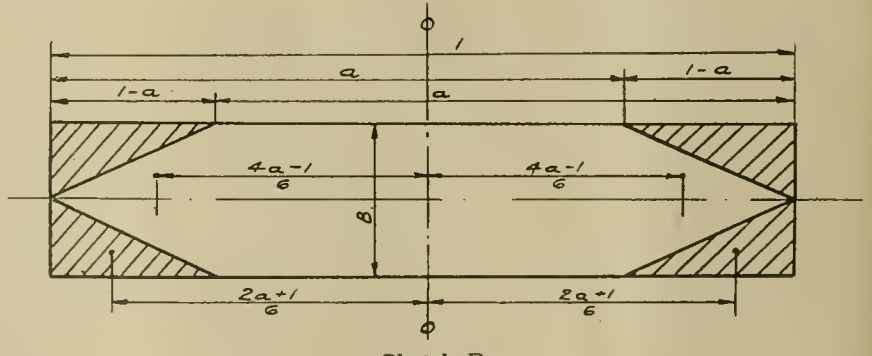
where d = draught and b = block coefficient.

$\therefore$ $B M = \frac{(3a - 1) B^2}{24 b d}$;

for ship shape the 24 in the divisor is displaced by 25.

"For longitudinal metacentric height my formula is derived by the same method as follows, again suppose the waterline is composed of straight lines as per sketch "B":—

"I_o of waterline about 0·0 equals I of total rectangle minus I of 4 external triangles shown cross-hatched, about 0·0, *i.e.*:—



Sketch B.

$$I_o = \frac{L^3 B}{12} - L^3 \left[\frac{B (1 - a)}{2} \left(\frac{(2a + 1)^2}{6} \right) + \frac{1}{36} B (1 - a)^3 \right] 2$$

$$= \frac{L^3 B}{12} (a - 2a^3 + 2a^3)$$

and $B M = \frac{I}{V} = \frac{L^3 \times B (a - 2a^2 + 2a^3)}{12 \times L \times B \times d \times b}$

$= \frac{L^2 (a - 2a^2 + 2a^3)}{12 b d}$

and moment to change trim per inch

$= \frac{L^2 B (a - 2a^2 + 2a^3)}{5040}$.

"Yours faithfully, G. H. Murray."

THE SEA TRANSPORT OF CHILLED OR FROZEN PRODUCE.

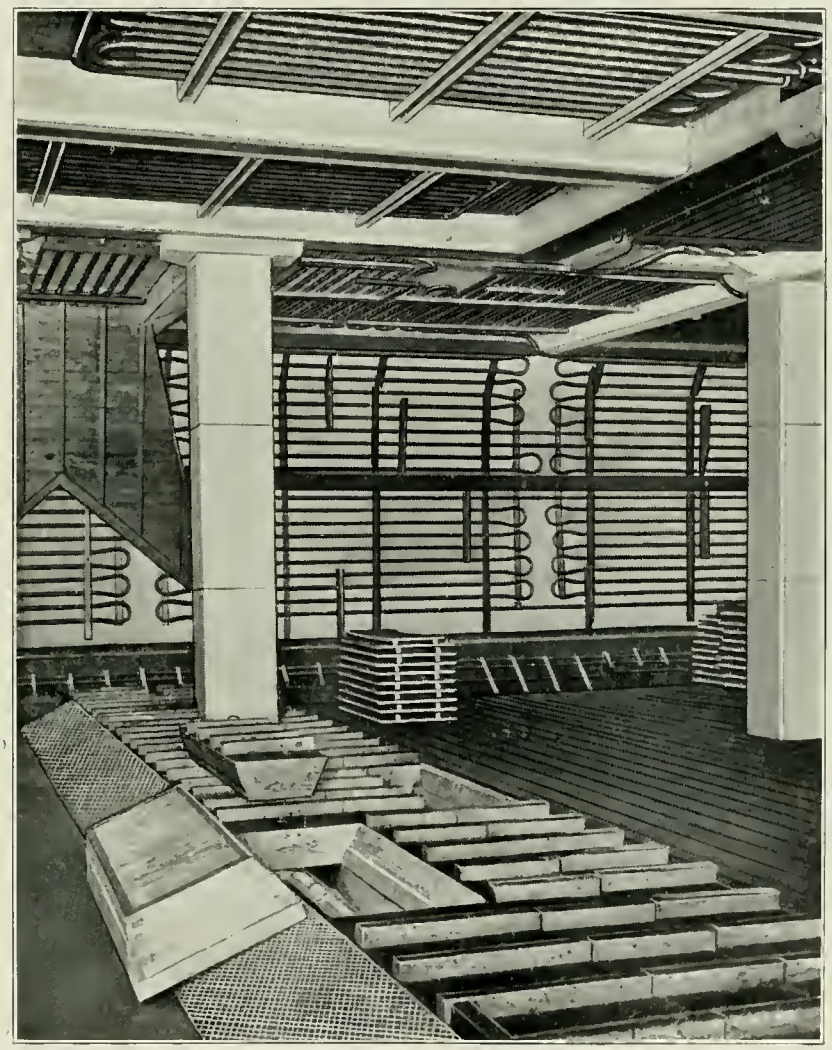
Refrigerating Arrangements on the Commonwealth Government Liners "Moreton Bay" and "Hobson's Bay."

One of the reasons for forming the Commonwealth Government Line of steamers was to provide facilities for traffic to and from Australasian ports, and the meat and fruit export trade of that country received careful consideration on the part of the promoters. Hence in all the five newest vessels built or building for the line in this country a great deal of space has been devoted to the storage of chilled and frozen produce, and the preparation of these spaces has received very careful attention on the part of the Government officials and builders alike.

It will be remembered that the new fleet is composed of five vessels, each having a gross tonnage of 13,850 tons with a length of 530 ft., beam of 68 ft. and depth of 43 ft. 6 in.

Comparatively little first-class accommodation is provided, there being in fact only 12 state rooms, but there are facilities for dealing with 700 third-class passengers.

The dimensions, tonnage and general arrangements are similar in all five vessels, two of which have been built on the Clyde at the yard of William Beardmore & Co. Limited, Dalmuir. The remaining three have been built by Vickers Limited, Barrow-in-Furness, and it is with these three vessels that we are particularly concerned in the following description.



Insulation at Centre Line showing Access to Bilge Suction.

The space devoted to cargo is divided as follows: Six holds and 'tween deck spaces, and of these, four holds—Nos. 2, 3, 4 and 5—and six 'tween deck spaces Nos. 2 and 3, upper and lower 'tween decks and Nos. 4 and 5 'tween decks, are fitted for refrigeration and are insulated, the measurements being:—

	Length.	Height.	Breadth (at deck).
No. 2 Hold	57 ft. 5 in.	17 ft. 0 in.	66 ft. 3 in.
No. 3 ,,	72 ,, 0 ,,	15 ,, 3 ,,	68 ,, 3 ,,
No. 4 ,,	50 ,, 8 ,,	24 ,, 3 ,,	68 ,, 3 ,,
No. 5 ,,	50 ,, 8 ,,	25 ,, 3 ,,	65 ,, 2 ,,

In addition to this there are the spacious refrigerated provision rooms for dealing with the consumable stores required by the passengers and crew during the course of the voyage.

Refrigerated Spaces.

The total capacity of the refrigerated spaces amounts to 378,500 cub. ft. available for cargo. Any form of cargo is liable to be carried on the outward voyage, and special attention has been given to this point in providing the necessary strength in. and protection to, the insulation wherever it could sustain damage from heavy weights.

Refrigerating Machinery.

The refrigerating system has been installed by the Liverpool Refrigeration Company Limited, and is on the CO_2 principle, consisting of two horizontal marine type machines, two independent CO_2 gas condensers and two independent CO_2 evaporators, with the necessary contingent water and brine circulating pumps, brine distributing piping and air circulating fans, &c.

The brine distributing pipes are $1\frac{1}{2}$ in. nominal bore with $1\frac{7}{8}$ in. full o/d and are arranged generally in the proportion of:—

1 running foot per 3 cub. feet capacity in the upper 'tween decks.

1 running foot per 4 cub. feet capacity in the lower 'tween decks.

1 running foot per 5 cub. feet capacity in the holds.

The brine system is on the three-temperature principle, provision being made for varying the temperature of the brine so that either frozen or chilled produce can be correctly dealt with while the brine can be heated by passage through a steam heater for thawing out the holds, &c., after discharge of the cargo.

The installation was as usual subjected to tests on the part of Lloyd's Register and the Government officials, which were successfully passed.

CO_2: 60 bottles of 40 lb. capacity each were used for the initial charge, the gas being supplied by the Washington Chemical Company Limited from their Bootle Works, and

sufficient reserve of gas is carried in bottles for "topping-up" if and as necessary during the voyage.

Calcium Chloride: 25 tons of this material were required for the initial charge of brine.

Insulation.

The insulation throughout has been installed by Newalls Insulation Company Limited, of Newcastle-on-Tyne, who have fitted their own "Nonpareil" sheet cork by their "Newsulate" system, embodying an unbroken cement finish, reinforced with light expanded metal.

The specification for the insulation was drawn up by Vickers Limited in collaboration with the Government officials and the insulating contractors, and was submitted to Lloyd's for approval. The following thicknesses of sheet cork are called for in the different portions of the ship:—

Ship's Side.—Three layers of "Nonpareil" sheet cork, each 3 in. thick with 4-in. granulated cork in holds and 1-in. granulated cork in 'tween decks.

Overheading.—Two layers of "Nonpareil" sheet cork each 4 in. thick.

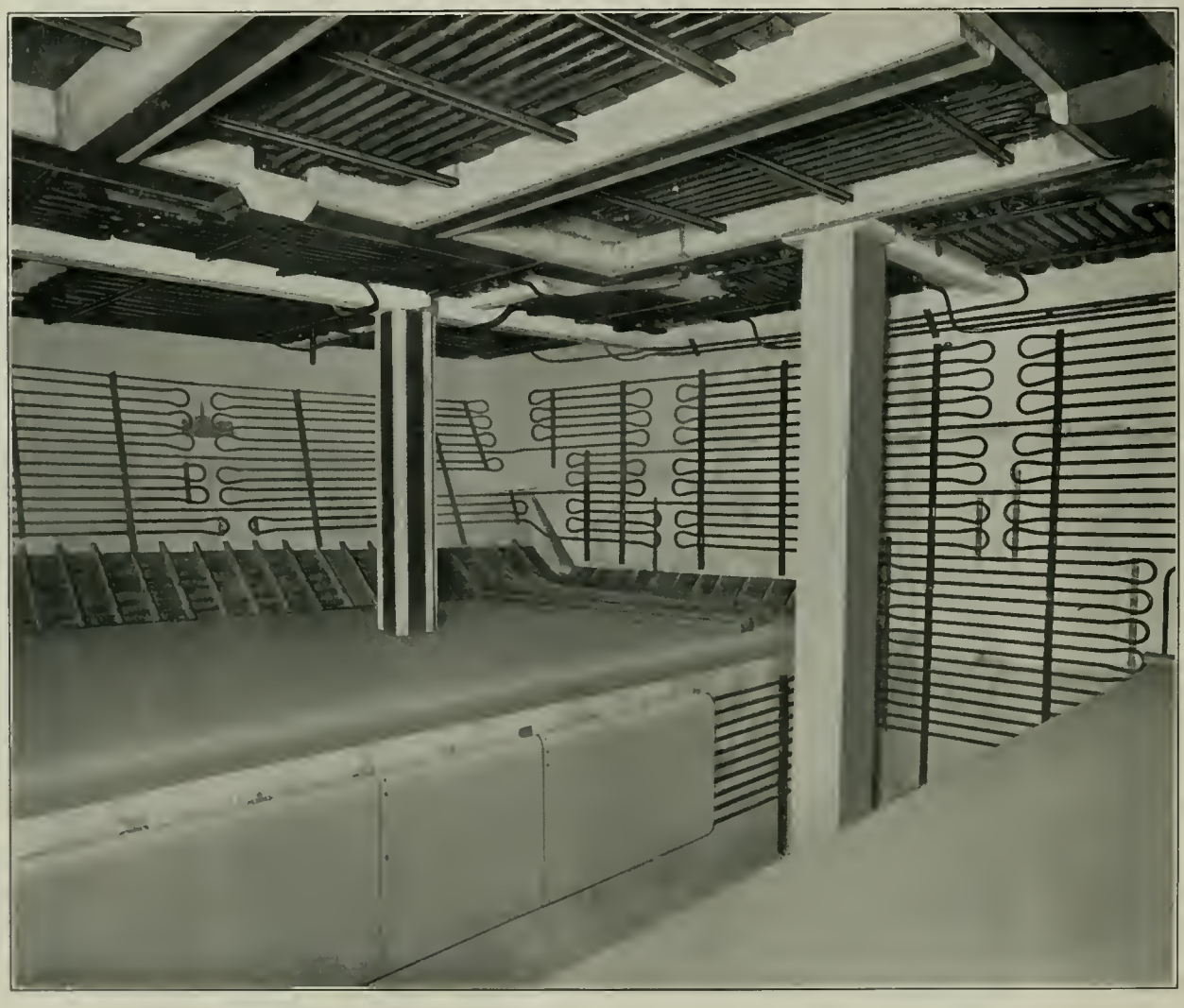
Tank Top (including tunnel top).—Bitumen, 1½ in., followed by two layers of 3-in. sheet cork and then 1-in. bitumen, with 2-in. pitch pine ceiling over all.

Tunnel Side.—Two layers of "Nonpareil" sheet cork each 4 in. thick.

The specification states that the vessel "is to trade between England and Australia and classed to Board of Trade and Lloyd's requirements, including Lloyd's refrigeration certificate. Spaces to be insulated to maintain a low freezing temperature for the carriage of frozen meat in carcase, rabbits, butter in cases, &c."

The conductivity of 2-in. "Nonpareil" sheet cork is known to be 3·2 B.Th.Us. per square foot per degree difference in temperature per 24 hours.

The sheet cork is arranged always to project 1 in. beyond the face of the ship's framing or beams, and also 1 in. beyond the toes of the bulkhead stiffeners. Where the beams or stiffeners exceed in depth the specified thickness of sheet cork, an air space is thus formed against the ship's side or underside of deck and this space is filled in with granulated cork.



Insulation of Lower Hold of Commonwealth Government Liners, showing Tunnel Top.

Erection of Insulation.

A special system of wood grounds is primarily installed on the beams and stiffeners or on special brackets and lugs to facilitate the erection of the sheet cork. This is then applied in multiple layers of 2 in., 3 in., or 4 in. thickness—all joints, both vertical and horizontal, being "broken" or overlapped in respect to the preceding layer—each subsequent layer being cemented to its forerunner by a coating of special adhesive Bitumastic cement additionally secured by means of cane skewers. The whole surface of sheet cork is then encased in light expanded metal of about ¾-in. mesh, rigidly secured, and this is then coated with a continuous and unbroken facing

of cement ½ in. to ⅝ in. thick. This cement, while setting extremely hard and being proof against vermin, moisture and fire, possesses certain elastic properties, which it is claimed render it free from any tendency to crack owing to the working of the vessel in a heavy sea.

Insulated Doors to Experimental Chambers.

There is of course no pointing or cementing of joints visible and a very pleasing general effect is thus obtained, while such troubles as settling and dry rot, prevalent with loose-packed insulation, are entirely eliminated.

A more detailed description of the method of insulating certain parts of the ship will prove of interest.

Tank Top.—A first layer of Bitumastic cement 1½ in. thick is followed by two layers of 3-in. sheet cork, which are laid between white pine grounds 8½ in. by 2 in. These grounds are secured—at intervals of one to each frame space—to lugs electrically welded to the tank top, and finally support the 2-in. pitch pine ceiling, but before this is laid down a second layer of Bitumastic cement 1 in. thick is applied on the top of the sheet cork. The total thickness of material on the tank top is therefore 10½ in. made up as follows :—

(*a*) 1½-in. Bitumastic cement.
(*b*) 3-in. "Nonpareil" sheet cork.
(*c*) 3-in. "Nonpareil" sheet cork.
(*d*) 1-in. Bitumastic cement.
(*e*) 2-in. pitch pine ceiling.

The joints of the ceiling are finally payed and caulked with one thread of oakum.

Pillars.—The square pillars are insulated with 1-in. sheet cork encased in 1½-in. T. and G. boarding, the corners being protected by galvanised steel nosing. Thermometers and sounding tubes are similarly treated.

Round pillars have a first layer of 1-in. hair felt sheeting and are finally wound in 1½-in. hemp rope.

Tunnel Top.—This is treated in a similar manner to the tank top with the exception that the thickness of sheet cork is increased to 8 in. directly over the shaft tunnel.

Bulkheads.—The bulkheads adjacent to the engine room, boiler room and reserve oil bunker respectively, have a special sheet steel lining forming an air space from 2 in. to 5 in. in depth between the bulkhead and the insulation.

Against this sheet steel lining is first applied "Aegis" asbestocel sheeting 3 in. thick, held in position by wood grounds carried on special lugs projecting from the bulkhead. Following the asbestocel is 8 in. of sheet cork with the usual reinforced cement finish. The space occupied by the insulation will thus be seen to be :—

(*a*)	Air space	2 in.
(*b*)	Asbestocel	3 ,,
(*c*)	Sheet cork	8 ,,
(*d*)	Cement	½ ,,
	Total	13½

Main Hatches.—The main cargo hatches were manufactured and fitted by Vickers Ltd. at Barrow, and consist of heavy bevelled pitch pine coamings fitted with plugs formed of double thickness 1-in. wood lining containing 6 in. of granulated cork, total thickness 10 in. The usual wood covers are provided over the plugs.

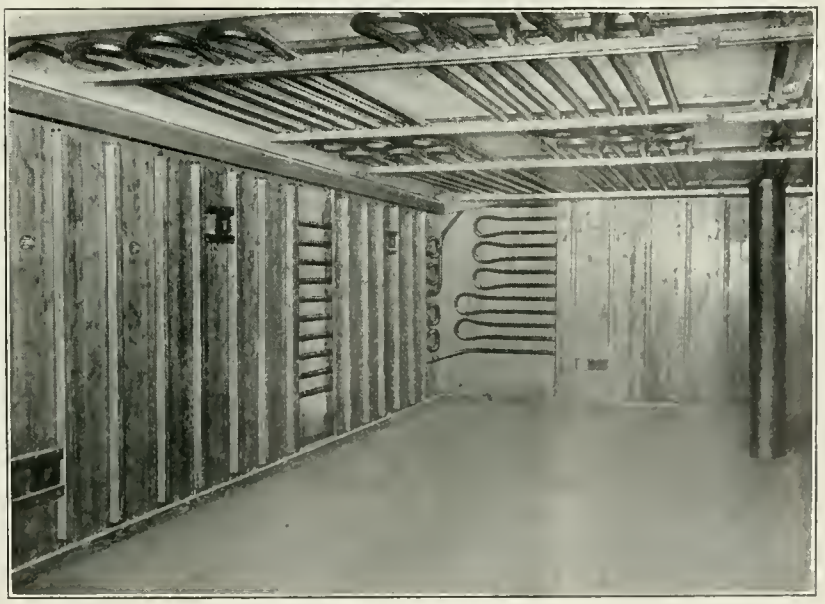
Escape and Bilge Hatches.—The whole of the minor hatches and insulated doors, together with their coamings and frames, have been made by Newalls Insulation Company Limited, at their shops in Glasgow and fitted by them at Barrow.

On the top of the tank side knees ordinary ceiling 2½ in. thick is fitted, provided with a portable portion 15 in. wide which runs the whole length of holds Nos. 2, 3 and 4, both on the port and starboard sides, and situated over the bilges.

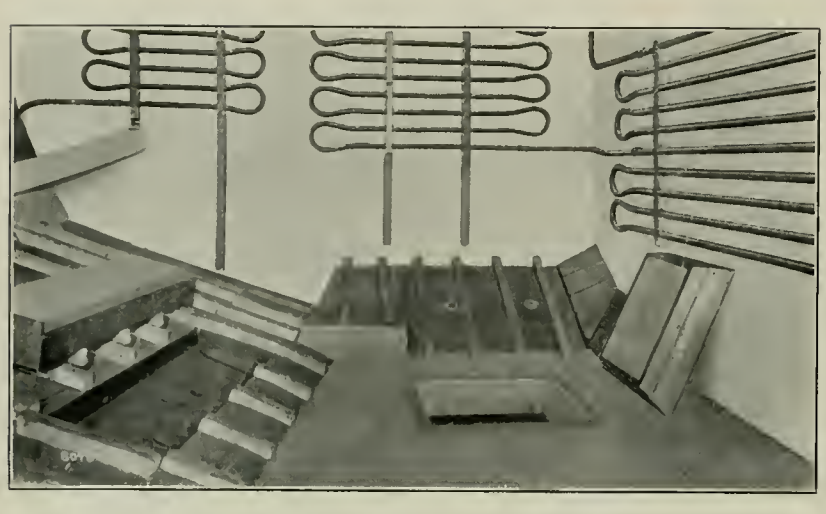
Access to this portable ceiling, and through it to the bilges, is provided by means of removable plug hatches, 7½ in. thick, and in lengths of slightly over 5 ft. each.

Pitch pine coamings 8 in. high carry the plugs which, to facilitate re-seating, are fitted with corresponding ½-in. checks. The ceiling below the coamings and adjacent insulation is primarily covered with sheet zinc to exclude rats from the holds. All plugs have tenoned corners, not less than 4½ in. thickness of sheet cork, and are covered with sheet zinc on the underside.

At the centre line of Nos. 2 and 3 holds similar plug hatches are fitted over the bilge suction pipes which run along the tank



Portable Fruit Screens with Air Ducts.



Commonwealth Government Liners. Insulation in way of Bilges.

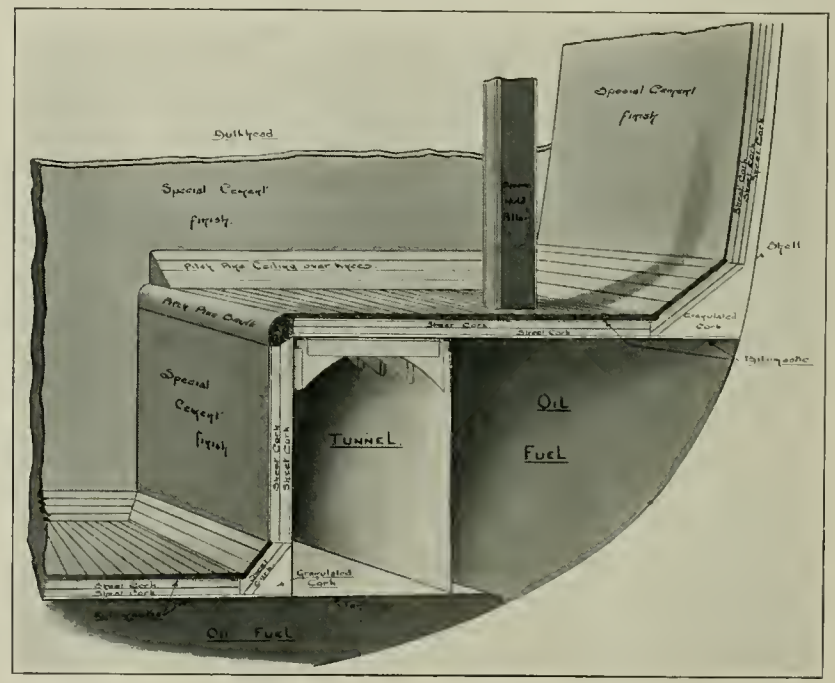
top. The coamings are bolted to lugs which are electrically welded to the tank top, and the plugs are fitted with four through ring bolts to facilitate removal after being subjected to pressure of heavy cargo.

Experimental Chambers.—A somewhat unusual feature is the provision of two experimental compartments which are formed at the after end (starboard side) of No. 4 'tween deck. A space of some 2,500 cub. ft. capacity, divided into two rooms, has been walled off by means of a partition formed of sheet cork with the usual cement facing and provided with insulated doors.

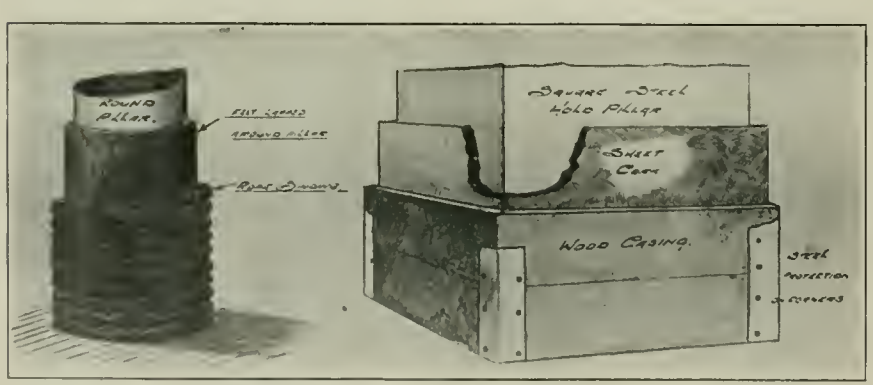
Facilities thus exist for carrying out tests on a practical scale but without necessarily involving the larger spaces.

Fruit Carrying.

Approximately 225,000 cub. ft. of cargo space is adaptable for carrying fruit, and portable fruit screens, forming an air duct for the circulation of cold air, have been made and fitted by Vickers Ltd. in Nos. 2 and 3 holds and 'tween decks. When carrying chilled cargo the overhead brine piping is shut off from the system.



Details of Insulation of Tunnel Top of Commonwealth Government Liners.



Details of Insulation of Round and Square Pillars.

Tests.

The tests on the two completed vessels have proved the refrigerating installation to be most satisfactory. In 22 hours, with two engines running, the holds and 'tween decks were cooled down to an average temperature of less than 40° Fahr. When the engines were stopped the rise in temperature over a period of 20 hours amounted to 12·5° Fahr., and as an indication of the efficiency of the insulation it may be mentioned that during the last 12 hours before the test terminated, readings showed a mean rise in temperature of only slightly over 4° Fahr., while during the last four hours the rise was only 1° Fahr.

The *Moreton Bay* has already made one voyage to Australia, the *Hobson's Bay* has just taken up work on the new service, while the third vessel, *Jarvis Bay*, is rapidly nearing completion at Barrow and should leave there in the early part of April.

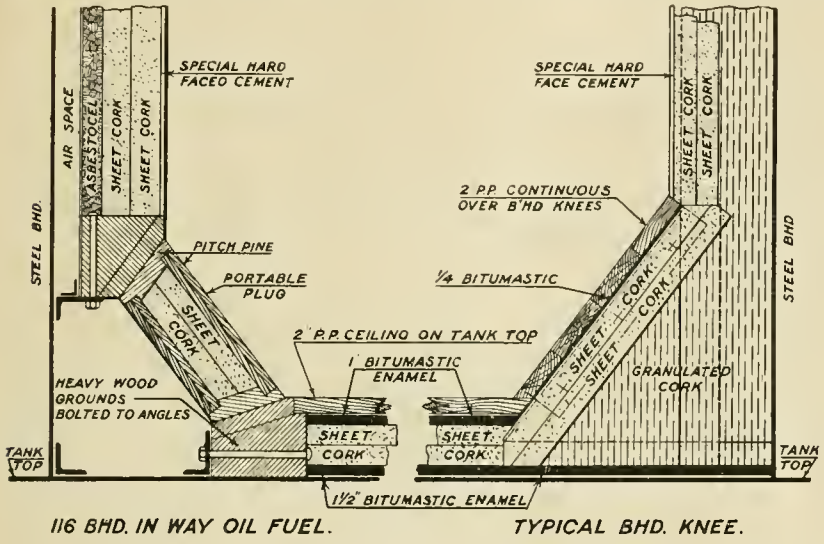
It is interesting to note that the *Boorara*, another of the Commonwealth Government liners, which is now undergoing a refit at Antwerp owing to extensive damage by fire, is being reinsulated by Newalls Insulation Company Limited with their own material and system.

Deck Caulking Machine.—A new deck caulking machine has been put on the market by John M'Dowall & Sons, shipyard tool and wood-working engineers, Johnstone, near Glasgow. The machine, called the "Clyde" deck caulking machine, consists of a motor, controller, resistance, crawling and cross-travel gear, &c., but the chief feature is an apparatus termed the "extended seam." This is a hollow guideway so constructed and placed as to form an outward and upward extension of the seam to be packed. Within the tapered opening formed by the adjustable walls the oakum is compressed by the hammer, and passes downwards and enters the seam in a partially-compressed state, where it is easily driven into place by the point of the hammer. The machine will caulk upwards of 40 ft. per minute.

MODERN MARINE STEAM TURBINE ECONOMY.

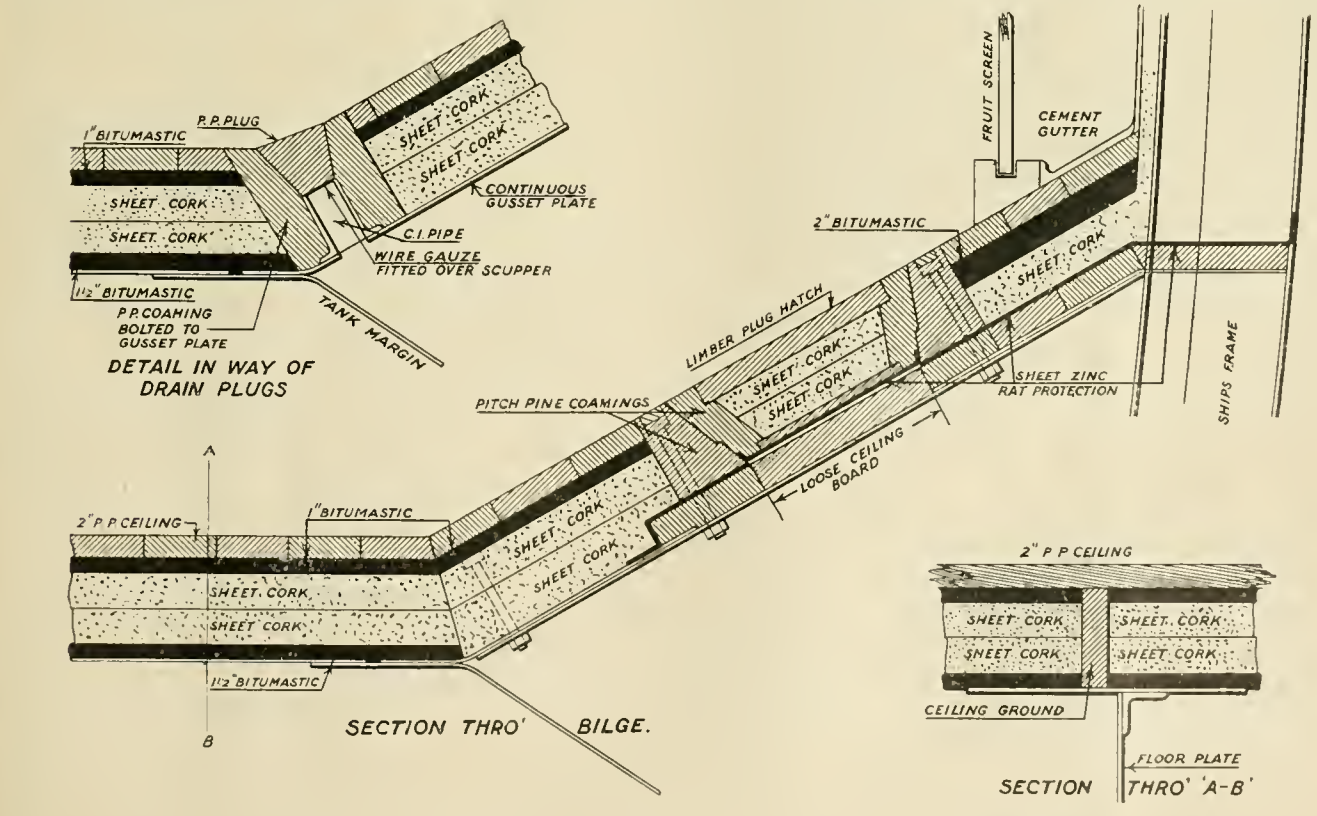
Land and Marine Turbines Compared—Direct Drive versus Reduction-Geared Turbines—The Effect of Higher Gearing Ratio and Increased Turbine Revolutions on Efficiency.

The improvement which has taken place in the steam consumption per horse-power of main propelling machinery during the last 25 years has recently reached a point in the latest types of geared turbine beyond which it is becoming increasingly difficult to effect much, if any, further reduction except at disproportionate cost. Now that marine turbine revolutions can be selected almost without restriction, instead of, as heretofore, being limited by the minimum size of propeller necessary to avoid cavitation, the conditions in the design of turbine proportions differ little from those met with in the best land station practice, and there is now no difficulty as regards weight and space required in selecting dimensions to give the maximum "hydraulic," or efficiency of kinetic energy, absorption for each type of blading between the limits of pressure and vacuum adopted such as were encountered in the days of the direct-connected turbine, when the ratio of blade speed to steam speed had to be sacrificed to meet the limitations imposed. The principal divergence between land and marine work to-day lies mainly in the facts that the latter is almost invariably geared, whereas alternators now permit of almost any suitable speed of rotation up to and beyond the requirements of the turbine, that whereas pressures and superheats ashore have been very greatly increased during the last ten years, the former has remained comparatively constant at a maximum of 200 lb. in mercantile vessels and about 240 lb. in naval practice for a much longer period, and that the latter is still far from being fitted afloat to an extent commensurable with its advantages or comparable with its adoption ashore. In land practice, 300 lb. boiler pressure and 250° to 300° Fahr. superheat are common, and even higher boiler pressures are being introduced. There is little scope for any improvement in vacuum, beyond lowering the cost of obtaining it, in view of the fact that 95 to



116 BHD. IN WAY OIL FUEL. *TYPICAL BHD. KNEE.*

T.S.S. "Moreton Bay"—Insulation Details.



T.S.S. "Moreton Bay"—Insulation Details: Section through Bilge, &c.

97 per cent. of the barometer is readily secured: in fact, practically the only limit now lies in the temperature of the available cooling water. Roughly speaking, in the course of the last decade the total heat drop per pound of steam in large electric power station work has been increased from about 400 to 480 B.Th.U's., or by 20 per cent, the former figure likewise representing a big advance on practice in 1900. In marine work the lower figure is about the maximum available to-day, and this is fully 10 to 15 per cent. more than the average case in which superheaters are not installed. The Manchester Corporation have at work boilers of 375 lb. pressure and 265° Fahr. superheat, and use 29·1 in. vacuum for their large turbines, giving a heat drop through the machine of 485 B.Th.U's. It is true that in land station work demanding the highest turbine efficiency two factors are involved which, in general, differentiate the conditions from marine work. First, except for very isolated examples, such as H.M.S. *Tiger*, *Renown* or *Hood*, which have from 110,000 to 150,000 h.p., the horse-power installed is very much greater than is met with afloat, even the *Mauretania* possessing considerably less power than Chelsea or Dunston stations, and secondly, the conditions of operation, particularly as regards change of load, reversing, and the question of the working of the auxiliary machinery, are very different. A point is reached in all installations, depending largely on their power, when the consequential effect of increase in capital cost, made to secure economy, becomes equal to and then greater than the possible saving due to the increase. It is virtually impossible to obtain higher vacua, and the only means then of extending the thermal range is to go up in pressure and superheat.

Theoretical Gains.

The advantage of doing this in marine work is problematical and requires careful consideration. In the first place, while the theoretical gain in economy, due to increase of pressure above 200 lb. gauge, is about 2·25 per cent. for 250 lb., 3·75 per cent. for 300 lb., 5 per cent. for 350 lb. and 6 per cent. for 400 lb., the *actual* gain is much less and varies considerably, both with the power and with the turbine speed. A double-reduction set running at 3,000 revolutions will gain more than a single-reduction set at 1,500, but for low-power installations—and the majority of single-screw vessels are below 5,000 s.h.p.—the gain is only small. In a twin-screw channel steamer of 10 or 14,000 h.p., increasing the boiler pressure from 200 to 300 lb. would probably only mean an actual gain of about 2·5 per cent. With powers exceeding 10,000 h.p. per shaft it should be rather more, but a saving of, say, 4 per cent. with turbines running at 1,500 r.p.m. will only be possible in very large sizes and with the pressure increased to about 350 lb. This is far from impossible with water-tube boilers: 300 lb. was the standard for the Belleville boiler for many years. Improvement in economy due to superheating is more independent of size and speed of rotation, and may be taken as being equal to about 1 per cent. for every 10° Fahr. up to 100° Fahr. superheat, about 1 per cent. for every 12° Fahr. between 100° and 150° Fahr., and above that about 1 per cent. for every 15° Fahr.

Measuring Steam Consumption.

Actual measurements of steam consumption of marine reciprocating engines were very rarely made prior to the introduction of the turbine, and in the early days of its development this lack of data was severely felt. The measurements made by the Committee of the Institution of Mechanical Engineers in the early 'nineties and those of the Boiler Committee ten years later were among the few reliable records available. Among the latter, the figure of 13·47 lb. per i.h.p. per hour for the R.M.S. *Saxonia's* quadruple expansion engines was perhaps the most interesting. With 192 lb. in the high-pressure receiver and 25·35 in. vacuum in the condenser, this meant a thermal efficiency of 17·2 per cent. and a thermal efficiency ratio of 62·8, which was undoubtedly a good result. The figure, however, led to some misunderstanding, the opinion being formed that it was representative of reciprocating practice, whereas in fact it was exceptionally good. The Admiralty cruiser machinery, with which it was compared, were designed to give the best results at about two-thirds of full power, at which the *Minerva* reached 65 per cent. efficiency ratio and the *Hyacinth* 54 per cent.; at full power these fell to 56·2 and 51·4 per cent. respectively, the latter falling off to even 46·3 per cent. at maximum power. When the light cruisers *Amethyst* and *Topaz* were tested against one another the turbines of the former showed a tremendous saving over the latter, but the *Topaz* happened to be a particularly inefficient design. H.M.S. *Dreadnought*, with 14·4 lb. per s.h.p. for turbines only at full power, the R.M.S. *Lusitania*, with 12·75 lb., and the battle cruisers of the *Invincible* class with 12 lb., were all typical instances of large direct-connected turbine performance, and if the mechanical efficiency of the *Saxonia's* engines between the indicators and the tunnel shafting abaft the thrust block be assumed as 90 per cent., the resulting consumption of 14·78 lb. per b.h.p. forms a good illustration of the characteristic gain in thermal economy due to the turbine.

Introduction of Gearing.

The direct-connected marine turbine, however, has passed into history. The comparison between the *Vespasian* with her original reciprocating engines and with geared turbines substituted was one of the most important milestones in marine propulsion, but the economical results with the latter were far from being as good even for a 1,000-h.p. installation as they might have been had the turbine been given a somewhat higher blading coefficient. The triple expansion engine obtained 1 i.h.p. for 16·95 lb. of steam with 128 lb. in the high-pressure receiver, 25·2 in. vacuum at the low-pressure exhaust and 26·5 in. in the condenser. The geared turbine got down to 14·3 lb. per s.h.p., with 121 lb. in the high-pressure receiver and 28·5 in. vacuum when running at 73·3 propeller revolutions; when running at 70, as did the engine, the figure rose to about 15·0 lb., which, taking 90 per cent. mechanical efficiency for the engine, or $\frac{16 \cdot 95}{\cdot 9} = 18 \cdot 83$ lb. per b.h.p., showed a great saving for the first geared installation. In the next set—the cross-channel steamer *Normannia*, of 5,000 s.h.p.—12 lb. per s.h.p., or a thermodynamic efficiency of 65 per cent., compared with the *Vespasian's* test of 55 per cent., was reached. In his last paper to the North-East Coast Institution of Shipbuilders, Mr. R. J. Walker published a number of guaranteed consumptions for double-reduction sets of various powers with 200 lb. steam pressure and 28 in. vacuum. For some of these the usual high-pressure and low-pressure two-pinion design was adopted, for others, intended for rather superior economy, high-pressure and intermediate-pressure turbines were fitted to the first pinion shaft. All these guarantees, however, indicated a designed efficiency ratio of over 72 per cent., and there is no reason at all why with Parsons blading this figure should not be easily obtained. The corresponding consumption per s.h.p. with 200 lb. to 28 in. is about 10·25 lb., which could be reduced to about 9·25 lb. with 100° Fahr. superheat. Parsons geared sets running at 11 to 11·5 lb. are common.

Land Practice.

The best steam consumptions obtained in British land turbine practice have been got with the Parsons two-cylinder 10,000 kw. turbines at Carville power station. The actual result, corrected for the very slight variation on test from the guaranteed conditions of 250 lb. gauge steam pressure at stop valve, 300° Fahr. superheat and 28 in. vacuum, gave a consumption of 10·08 lb. per kw. hour as an average for five machines, one of which had been running for 4½ and another for 2½ years before the trials were made in 1920 and 1921 under the auspices of the Steam Testing Department of the Newcastle Electric

Supply Company. The actual average overall thermal efficiency of these machines was 25·6 per cent., and the efficiency on the Rankine cycle 73·84 per cent. There was a drop in steam pressure of 22 lb. from the boiler side of the stop valve to the high-pressure inlet, and the latter efficiency becomes 74·76 when using this pressure. For the turbine only—that is, taking the generator efficiency of 96 per cent. into consideration—the mean efficiency on the inlet pressure was 77·84 per cent. These machines ran at 2,400 revolutions, so that the turbine was working under exceptionally good conditions as to revolutions for the power developed, but the figures afford indisputable proof that consumptions corresponding to 70 per cent. efficiency between turbine inlet and s.h.p. are obtainable in marine work with reaction turbines. The average actual steam consumption per s.h.p. at turbine coupling in this case was 7·72 lb. per hour.

There is an unfortunate tendency sometimes to misapply consumptions quoted for one type of turbine as being those obtainable from others: very few consumptions for geared turbine installations with impulse turbines have been published. For the United States battleship *New Mexico* with electric drive the consumption per s.h.p. with 250 lb. and 28·5 in. was 11·58 lb.; the efficiency of motors and generators combined was 92·6 per cent. at full power, so that the turbine only required 10·7 lb. The figures for the shop tests against a generator for the Rateau turbines of the S.S. *Assiout*, made by the Metropolitan-Vickers Company, when corrected to their guarantee conditions of 180 lb. pressure, 100° Fahr. superheat, and 28·5 in. vacuum, showed a consumption of 10·49 lb. per s.h.p. and an efficiency ratio of 66 per cent. This installation developed 2,500 s.h.p. through double-reduction gearing, the turbines running at 2,500 and the propeller at 70 revolutions.

Confining consideration to the economy of the turbine only, it follows that it is now very hard to obtain any markedly superior results in marine work. One direction in which progress can, and undoubtedly will be made, lies in increasing the gearing ratio and running the turbines still faster. A big double-reduction set of 12,000 h.p. on two shafts and recent construction runs at 3,000 revolutions. This is rather less than would be adopted in land work for generating purposes, 3,600 revolutions for a 5,000 kw. machine being common to-day, and for smaller powers this speed seems likely to be increased to 4,000 and 5,000 revolutions. Pressures can only be increased by the adoption of water-tube boilers if any improvement be sought in that direction, but a more general use of superheat and of higher superheats seems the most probable direction in which further economy may be attempted. The recent guarantees for the suspended battle-cruiser machinery envisaged a full power consumption per s.h.p. of only 9 lb., and when the friction, leakage and other losses in the turbine, gearing and thrust block are considered, together with the maximum attainable "hydraulic" efficiency of the most efficient form of blading arrangement, it is difficult to believe that marine steam turbine economy is not now approaching finality.

THE TRAINING OF A MARINE ENGINEER.

Apprenticeship Systems—Higher Board of Trade Standards—Increasing Need for Higher Technical Education—Discussion.

At a time when marine engineering practice is undergoing epoch-making changes and when we are compelled to realise more and more that progress in methods of marine propulsion has no finality, anything tending to stimulate interest in a factor of such importance to future progress as the training of the young engineer is as welcome as it will be helpful. In a paper entitled "The Marine Engineer in the Making," read by Mr. Peter Youngson, B.Sc., before the Liverpool Engineering Society on March 8, the author examined the merits and demerits of the several existing systems and traced the progress made in the last twenty years. The author, we believe, enjoys the distinction of being one of very few engineers in this country who combines a university degree in engineering with the premier Board of Trade certificate, but were he not also the pioneer in the preparation of marine engineers on educational lines as far back as 1903, we should yet regard him as one of the leading authorities on this question.

The average period of apprenticeship is one of five years—between the ages of 16 and 21. A boy attending a secondary school does not as a rule matriculate before the age of 16–17, and although the employer would be quite willing to take him as an apprentice at the latter age, he could not, owing to trade union regulations, retain him after the age of 21. This arrangement is very unfortunate and prevents many desirable boys entering the profession. They either have to break off their education at an important stage or they are unable to serve the full five years. The war taught us many things, but established usages and customs are difficult to alter, and the manual training during apprenticeship still follows the old lines. Boys learn to handle the tools only by the spirit of emulation, and in all works of any size there should be at least one manual instructor to initiate the beginner and encourage the progress of the apprentices in the use and application of the implement and machines of their trade. It was agreed two years ago that this would prove a paying investment for the employer, yet it is surprising that it has never been put into practice.

The qualifying sea service for a second-class Board of Trade certificate is 18 months on regular watch on the engines and boilers of a vessel of not less than 66 nominal horse-power. This service is estimated from the discharge book time on the ship's articles and does not include the time spent in home ports. Should a beginner sign on in a ship carrying three or four engines, he takes a watch at once, but in a liner with a staff of 20 or 30 engineers he may have to serve a probationary period of a year or two on day work before he is advanced to watch-keeping duty. Thus it will be evident that the engineer on a tramp steamer has better and earlier opportunities for obtaining his junior certificate than his liner colleague. To qualify for first-class engineer the further sea service is 18 months in charge of the whole watch in a small ship, or in charge of a definite portion of the watch in the big ships while holding a second-class certificate. The service must include both engine and boiler watch-keeping with a minimum of six months on either.

In 1916 certificates for service in vessels propelled by internal-combustion engines were introduced. The ordinary certificates are valid in oil-propelled ships only until January, 1924. The regulations for oil motor certificates and the subjects of examination are similar to those for steam certificates. The holder of a second or first-class ordinary certificate may apply to be examined in the appropriate oil engine examination, and if successful his certificate will be endorsed to show that he is qualified for service in a similar capacity in oil-propelled vessels. Candidates for endorsement must show a further sea service of nine months in oil ships; they are not examined in mathematics or drawing, and are only required to take the engineering knowledge papers of the oil-engine examinations and answer

verbal questions in the running and maintenance of Diesel and other oil engines. It is fairly safe to predict that 10 years hence the term "ordinary certificate" will be a misnomer. There is already great competition to serve in Diesel ships, and the engineers in these vessels are, as a class, technically superior to their confrères in steam.

Higher Standards Demanded.

In recent years the standard of Board of Trade examinations has been advanced enormously and this is all in favour of the technically-trained student. The author points out that the present system whereby examinations are held weekly is far from ideal, inasmuch as the chief examiner in London has only two professional assistants, and the average number of candidates is over 50 per week, which means that 150 examination papers have to be corrected in two days. This destroys the possibility of devoting the care and attention to marking which these papers merit, and moreover, it is impossible to get out 52 original sets of papers annually. For these reasons the adoption of a monthly system of examinations is recommended.

The examination for extra-first-class certificate demands a fairly high technical knowledge. With a chief's certificate and a five years' apprenticeship a candidate may sit without further sea service, but with only four years' apprenticeship an additional year must be served either ashore or afloat. It is stated that the number of passes in the past few years shows a decrease, and while this is in some measure due to the higher standards being set, a further factor is doubtless the increased cost of living which prevents many men from leaving a lucrative sea post and attending a school for six months, without wages. The absence of any definite syllabus and the high percentage demanded make it by no means certain that even a well-prepared candidate may pass, and men fresh from a course of engineering at a university have been known to fail. It is possible to have a university degree in engineering and yet have no practical training, but the extra-first-class engineer must have at least seven years' practical experience, and he thus possesses a combination of theory and practice not guaranteed by any other academic distinctions.

With the increasingly complex nature of marine machinery we believe it to be a fact that the ancient prejudice among superintendent engineers against anything savouring of technical, "academical," or "book" learning is rapidly disappearing. The practice among many of our greatest shipping companies in time past was to elevate their "commodore" or senior chief to the position of superintendent engineer, but in recent years this practice has fallen into abeyance and these companies in many cases now look for a man of high technical ability, and not always is it a *sine qua non* that he should have sailed in the vessels of the company. Nevertheless it is remarkable, in view of the foregoing, that of 700 marine engineers who, in the last three years, enrolled at one of our central technical schools only one had a degree in engineering, and he only qualified, as regards apprenticeship, owing to war service in the Royal Engineers.

Recognising the importance of higher technical education, the author proceeds to set out the various means by which it may conveniently be acquired. The methods set forth are :

Course I.- To proceed straight from school to the university.

Course II. To complete apprenticeship before attending university.

Course III. To serve two or three years in the works and then follow on with university training.

Course IV. To serve apprenticeship and take technical training on some form of the "sandwich" system.

In the first of these it is possible to graduate without any practical training whatever, and from a strictly practical standpoint this course has nothing to recommend it. Course II is the other extreme, and while it will produce good engineers, it has nevertheless this disadvantage that few young men can afford the unproductive period of three years between 21 and 24; moreover, by going to sea money may be earned and the engineer may qualify for extra-first-class certificate. Employers have frequently raised objection to Course III, inasmuch that when two years of his training are over the apprentice has arrived at a state of practical usefulness and thereafter proceeds to the university, to the employer's loss. The last method, known as the "sandwich" system, has, we believe, found much favour and has much to recommend it. By this system the young engineer's theory and practice march in parallel, and he will frequently find that the mechanical principles assimilated at the university will enable him the more readily to appreciate the practical problems of the workshop and drawing office.

The supremacy of our mercantile marine was built up largely as a result of the industry and efficiency of our marine engineers whereby our ships penetrated to far-flung ports of the world. If we would maintain that supremacy it is vitally important that the modern marine engineer keep well abreast of the practical developments in marine propulsion, and this can only be done by combining with sound practical training the highest degree of technical knowledge.

Discussion.

Following the reading of Mr. Peter Youngson's paper, a very interesting discussion took place.

Mr. Reney Smith remarked that he did not think examinations were the truest test of a man's knowledge because the man was nervous, especially if his livelihood depended upon him getting his certificate, and was over-anxious to get through in a short time. He thought the slower method of education, commencing in the young man's apprenticeship and then going forward to the technical school and university, gave them the best product. When putting in his time at sea a man forgot what he learned at school and had to go to a cramming school to get his certificate, He remembered trying to institute a system of examinations for their drawing office whereby no boy should go in unless he had a good record of his apprenticeship, but none of the boys applied or cared, and the basis of education was the desire to know. That was the spirit that was lacking at the present day.

Professor T. B. Abell said that at the Liverpool University they tried to train marine engineers and had some really good men who had had their works' experience and many had come from the technical school.

Mr. B. G. Oxford remarked that a university training was very desirable, but was the game worth the candle. He did not think so from a marine engineer's point of view. Mr. Youngson had raised the point about the trade unions limiting the age to 21 years. He did not think the trade unions objected to anyone serving an apprenticeship after he was 21 so long as he was not a paid apprentice. He thought it was a very wise provision. At the age of 21 he thought every man should be in a position to keep himself, and at the age of 25 should be in a position to marry. He did not think it was necessary for a man to learn foreign languages.

Mr. S. B. Freeman said Cammell Lairds had a very good system of reporting to the parents on their apprentices' progress, and when the young man came forward to apply for a seagoing position they could turn up four or five years of their record signed by the works manager. Mr. Youngson had said the engineer in the Diesel engine ship was the superior to his confrère in steam. He very much doubted whether that was going to be the case.

Mr J. B. Wilkie, President, cited a case where the knowledge of Spanish had secured an engineer an important appointment in Grand Canary. He thought there ought to be some inducement to men holding their "extra chief" certificate not to go to shore appointments but remain afloat, and suggested that a combined deck and engine room certificate should be founded which be maintained would produce a better type of master in the future.

HYDRAULIC FEED-WATER AUTOMATIC REGULATOR.

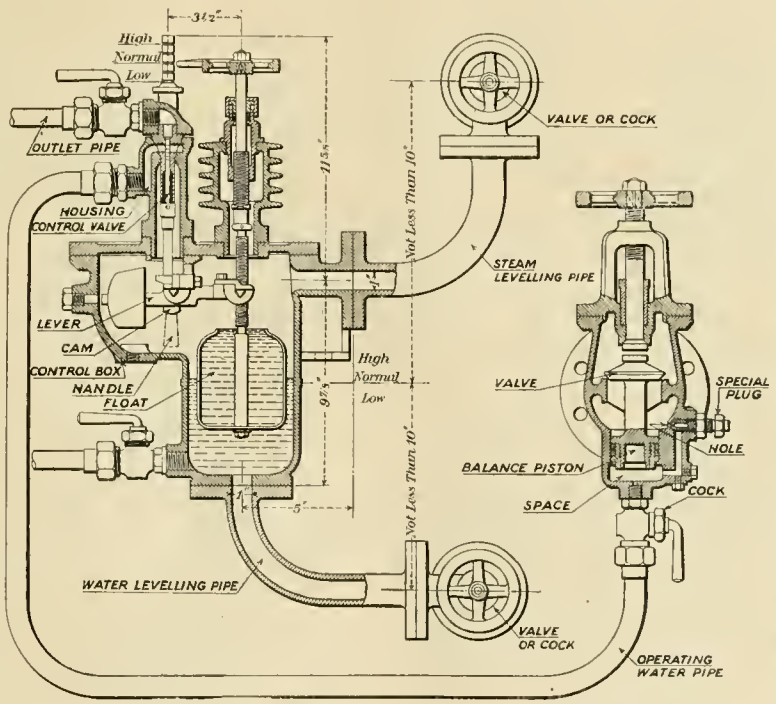
Some Features of the new Aster-Anthony Patent Hydraulic Feed-Water Regulator.

The limited amount of water carried in boilers of the water-tube type, together with the variations in engine speed and the fluctuations in steam pressure met with in marine practice, and, to a less extent, in shore installations, render necessary the adoption of some reliable and positive method of feed-water control which will eliminate, as far as possible, the human element, and will be automatic in its action. It is conceivable that such a method of automatic control might with advantage be employed in Scotch boilers with a consequent reduction in the amount of personal feed-control supervision, but the greater volume of water available in these boilers and the increased time-safety factor have militated against the adoption of automatic control in boilers of this type.

The Aster-Anthony Hydraulic Regulator.

We reproduce herewith a drawing showing the new and improved model of the Anthony Patent Hydraulic Feed Regulator, which is manufactured by the Aster Engineering Company Limited, Wembley, Middlesex. From the details shown, the action of this regulator will be readily visualised. Three special features claimed for this regulator are as follows:—

(*a*) Positive control of the operating water as opposed to leakage past the plunger.
(*b*) A seatless plunger control valve as opposed to the usual needle valve.
(*c*) Open float control combined with an air-cooled condenser as opposed to the closed float.



Diagrammatic Arrangement of the new Model of the Aster-Anthony Patent Hydraulic Feed Regulator.

Primarily the apparatus consists of a check valve carrying a balance piston, between which the feed delivery pressure is introduced, acting upwards on the valve and downwards on the balance piston. Full boiler pressure is superimposed on the check valve, which is normally held in contact with its seat by this pressure. A special plug fitted with a hole, as shown, allows a continuous but small quantity of water to pass to the space below the balance piston. So long as this water is allowed free escape the check valve remains closed, but if, by closing the hand-cock at the lower end of the operating water pipe, for instance, escape is shut off, the space immediately fills and equal pressures are exerted above and below the balance piston, rendering this piston balanced and inoperative. At this point the feed delivery pressure acting under the check valve opens this valve and allows the entrance of the feed water to the boiler in the usual manner. Whenever the water is again allowed to escape, the reduction of pressure under the check valve causes this valve to close, slowing down the feed pump, which continues to function at such slow speed as may be necessary for the by-passing of the water through the hole in the special plug until this by-passing is again interrupted. Thus we see that by controlling the escape of this very small quantity of water—estimated to be about 1 per cent. of the total volume of feed entering the boiler—we exercise the most sensitive and complete control over every movement of the check valve.

Automatic Control.

An operating water pipe conveys the water escaping from the space to the control box situated at the normal working level of the water in the boiler. In accordance with Board of Trade requirements, steam and water pipes, fitted with independent valves or cocks at the boiler drum or shell, are connected to the control chamber, so that the water level in this chamber corresponds with that in the boiler. Any variation in the boiler water level operates a float, which, in turn, operates the control valve contained in the housing, to which is attached the inlet operating water pipe. Briefly, the control cycle is as follows:—(*a*) the water level rises, raises the float, opens the control valve, permitting the operating water to escape and the check valve closes; (*b*) the water level falls, lowers the float, closes the control valve, and the check valve opens, admitting water to the boiler. When the operating water has passed the control valve it is not lost, but is diverted to the hot-well, feed tank, or feed pump suction, as the case may be, by means of the outlet pipe.

To Check Operation of Regulator.

In an apparatus controlling such a vital factor as the supply of feed water to a boiler under steam, it is important that some convenient and reliable method of testing whether the apparatus is functioning properly should be provided. Reference to the drawing will show that by means of a handle the float may be raised or lowered. The handle is attached to a cam which tilts the float lever when moved in either direction. As shown, the handle is in the central or neutral position and has no effect on the working of the float.

If it should be necessary at any time to examine the float chamber or control box, this may be conveniently effected by closing the hand-cock and the cocks or valves at the boiler ends of the steam and water pipes without interfering in any way with the working of the boiler, since when the hand-cock is closed, the check valve operates as a hand-regulated check. We understand that this regulator is in general use throughout the world with the sole exception of Japan.

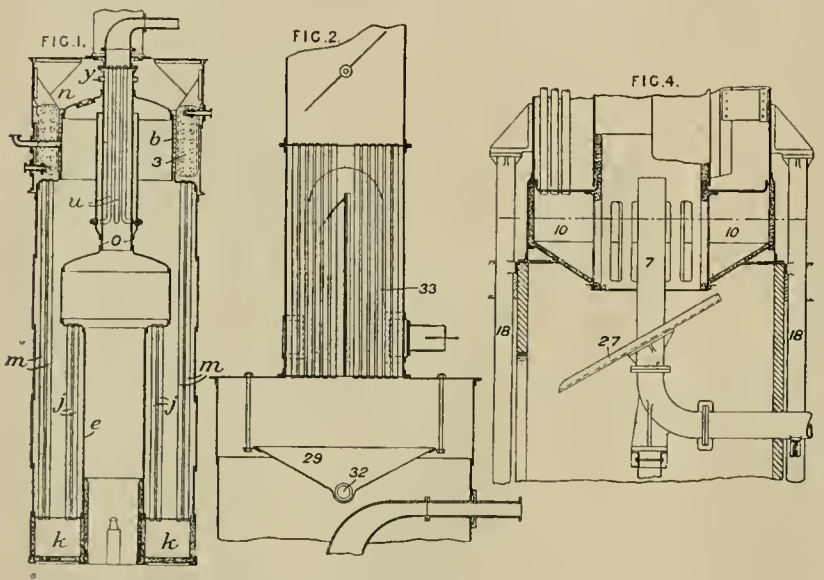
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 170,339. Steam Generators.

Cruse, H., 6, *Crumpsall Green, Manchester. May* 25, 1920, *Nos.* 14205, 23581, *and* 34064. [*Classes* 51 (i), 64 (i), 123 (ii), *and* 123 (iii).]

In a vertical boiler fired by oil, gas, or pulverulent fuel, a group of smoke tubes *j*, Fig. 1, conduct the combustion products from the top of the combustion chamber *e*, which does not extend above the water level, down to an annular flue *k* at the bottom of the boiler, and a second group of tubes *m* conduct them from the annular flue to a smoke chamber *n* around the steam dome *b*. The first group of

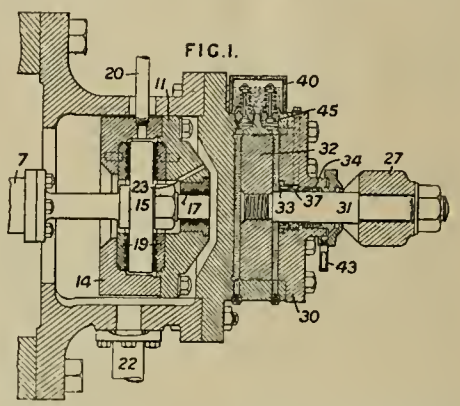


smoke tubes may be dispensed with; the products then pass downwards inside the combustion chamber around the incoming gases. Part of the products pass upwards through a central flue *o* opening into the smoke chamber through small apertures *y*. The central flue is fitted with a coiled or straight tube superheater *u*, as described in Specification No. 172,568. Feed-heating or steam superheating tubes 3 are arranged in the smoke chamber around the steam dome. The annular bottom flue 10, Fig. 4, has a base so inclined as to discharge ash on to an inclined tray 27 supported on the fuel-supply nozzle 7. The walls of the annular flue may be secured to the vertical standards 18 independently of the boiler shell. The combustion chamber may be made of curved vertical flanged plates connected together along their flanges and stayed to the boiler shell. A tray 29, Fig. 2, is fitted at the top of the smoke chamber to receive ash and soot, which is removed by a conveyer 32. The products may pass from the smoke chamber through an air heater 33.

No. 174,154. Turbines.

British Thomson-Houston Company Limited, 83, *Cannon Street, London.—(General Electric Company, Schenectady, New York, U.S.A.) October* 14, 1920, *No.* 29098. [*Classes* 12 (i), 108 (iii), 110 (iii), *and* 122 (v).]

Relates to devices for damping the axial vibrations of turbine shafts, particularly of the radial flow type having oppositely-running rotors, and consists in providing a thrust-absorbing member capable of axial movement and rigidly connecting it with the movable member of a dash-pot which is adapted to check quick motions but does not seriously interfere with slow motions, the thrust bearing and the dash-pot being so arranged relatively to one another that the lubricant of the thrust bearing cannot enter the dash-pot. Thus the turbine shaft 7 is connected to a thrust disc 15 which, together with bearing discs 19, is located within an axially movable thrust casing 11, 14 having trunnions connected by rods (not shown) with a yoke 27. This yoke engages the rod 31 of the piston 32 of a mercury dash-pot, which allows a slow transfer of mercury from one side of the piston to the other through the clearance between piston and cylinder. Mercury forced past the U-shaped packing 33 enters a chamber 37 in the head 30 of the dash-pot and flows upwards to a reservoir 40 which is open to the atmosphere and communicates with opposite sides of the piston 32 through pairs of inwardly opening valves 45. Should any mercury leak past the stuffing-box 34, it is caught in a container 43. The oil for the two sides of the thrust disc 15 is fed by a pipe 20 and discharged by a pipe 22, the duct 23 through which part of the oil escapes being arranged above the shaft and its bearing 17 to ensure a permanent

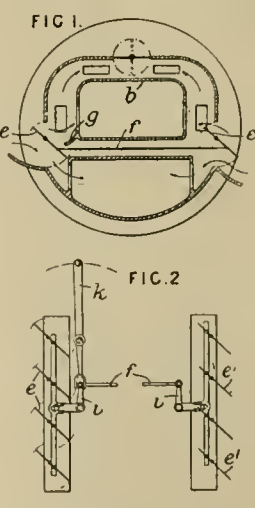


supply of lubricant to the latter. The oil and mercury systems unite to restrict the axial movements of the shaft 7, but are maintained entirely separate. Specification 19169/12 is referred to.

No. 172,165. Furnaces.

Reid, J., 4, *Lloyd's Avenue, London. September* 23, 1920, *No.* 27150. [*Class* 51 (i).]

In furnace fronts for steam boilers adapted for forced draught the supply of air to the ash-pit and to the casing surrounding the firing openings is controlled by valves *e*, e^1 connected by a rod *f* and arranged so as to turn simultaneously in the same direction, the left-hand valve serving to direct air downwardly towards the ash-pit and the right-hand valve serving to direct air to the air casing surrounding the firing opening *b*. The valves are pivoted towards their top edges to increase the valve opening at the bottom. A vane *g* directs the air entering above the valve *e* to the casing surrounding the firing opening. Instead of single valves, louvre valves of the form shown in Fig. 2 may be employed adapted to be operated by a lever *k*, connecting-link *f*, and bell-crank levers *i*. The valves may be interlocked with the furnace door to prevent it from being opened while the forced draught is on.

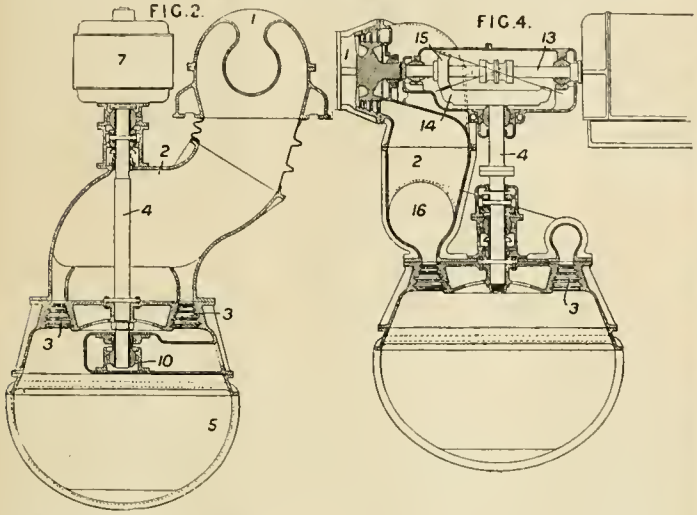


No. 172,094. Turbines, &c.

Parsons, Sir C. A., and Carnegie, A. Q., Heaton Works, Newcastle-on-Tyne. August 26, 1920, *No.* 24759. [*Class* 110 (iii).]

A compact steam-turbine plant is obtained by carrying the greater number of the rows of blades on the high speed shaft, the final rows of blades, in which a further small expansion of the steam takes place, being carried by a low-speed secondary shaft, electrically or mechanically coupled to work in parallel with the main shaft. Thus the main turbine portion 1, Fig. 2, having an horizontal

shaft, drives directly an alternator at the highest possible speed, and exhausts through a pipe 2 into a turbine section 3 which is of relatively small power and has its shaft 4 vertical or approximately so, the shaft 4 driving an alternator 7 coupled in parallel with the main alternator. The steam from the final stage passes directly to the condenser 5. The bearing 10 for the shaft 4 may be arranged as shown, or the shaft 4 may pass through the bottom of the con-

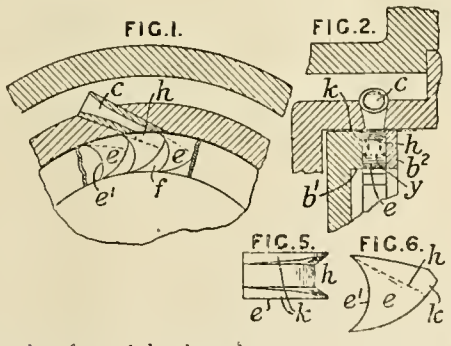


denser 5. The secondary shaft 4 may be horizontal and placed under the main shaft, the pipe 2 being kept as short as possible. Fig. 4 illustrates a construction wherein bevel gearing 14, 15 is used to transmit power from the shaft 4 to the main shaft 13, and a steam admission chest 16 of volute form is employed for the secondary portion of the turbine. In cases in which the shaft 4 is vertical or inclined, the stator of the secondary portion may be divided circumferentially into several parts, each of which can be readily withdrawn, being supported during withdrawal on shelves or slide rails.

No. 172,124. Turbines.

Binnie, J. S., St. Leonards, Kilmacolm, Renfrewshire. September 2, 1920, *No.* 25322. [*Class* 110 (iii).]

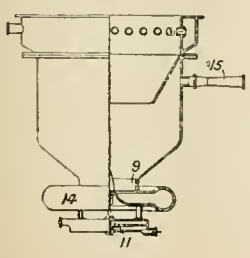
The rotor blades *e* of a turbine of the radial or axial flow type are formed with a channel *h* between diverging shoulders *k* and with



a curved active face e^1 having the same curvature throughout. The inlet to the channel *h* is slightly wider than the diameter of the jet *c*, Fig. 2, but less than the width *y* of the outlet passage *f* between the blades. By making the opposite side walls b^1, b^2 diverge, the shoulders *k* may be dispensed with. The blades may be secured by rivets passing through the walls b^1, b^2.

No. 172,298. Jet Condensers.

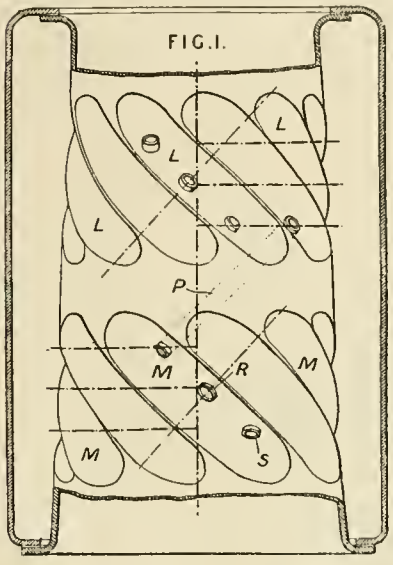
Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster.*—(*Assignees of Morgan, D. W. R.*, 218, *Dickinson Avenue, and Schmidt, H. F.*, 218, *Rutgern Avenue, both in Swarthmore, Pennsylvania, U.S.A.*) *November* 28, 1921, *No.* 31833. *Convention date, December* 3, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 32.]



A rotary pump 9 for removal of the cooling water and condensate is arranged to rotate in an horizontal plane. The pump 9 is driven by an impulse turbine 11 and discharges to a collecting chamber 14 from which it flows at atmospheric pressure. The pump 9 causes agitation of the water above it and entrains a considerable amount of air. Air-removing apparatus 15 may be provided.

No. 172,232. Steam Generators.

Alley, S. E., 17, *Iddesleigh House, Caxton Street, Westminster. January* 3, 1921, *No.* 18. [*Class* 123 (iii).]

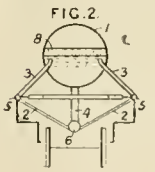


In a boiler of the kind in which inner and outer vertical cylindrical shells enclose an annular water space, and inclined straight water tubes extend across the inner shell, the ends of the water tubes are secured in two series of landings L, M, each in the form of helical depressions. The group of tubes P extending between the top of the landings M and the bottom of the landings L lie at the greatest angle to the axis of the shells, the next group R lying at a smaller angle, and the group S extending between the bottom of the landings M and the top of the landings L at the smallest angle. Specification 112,222 is referred to in the Provisional Specification.

No. 172,953. Steam Condensers.

Aktiebolaget Ljungströms Angturbin, 2, *Arsenalsgatan, Stockholm. December* 7, 1921, *No.* 32879. *Convention date, December* 18, 1920. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 29 *and* 32.]

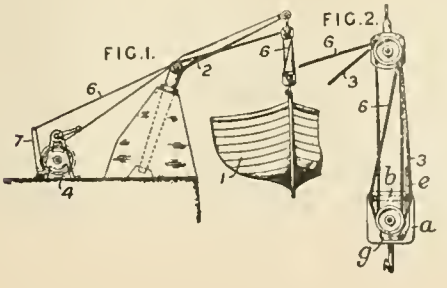
In a condensing apparatus for locomotive and like engines, the steam is passed into an elongated cylindrical vessel 1 containing liquid, which is pumped on to a perforated partition 8 and sprays downwards through the steam. The liquid is cooled by passage through pipes 3, opening near the surface to coolers consisting of end pipes 5, 6 connected by a series of flattened and ribbed pipes 2 exposed to the air. The cooled water returns from the pipe 6 by a pipe 4 to the base of the vessel 1. The circulation of the water may be aided by pumps. Horizontal fans below the vessel 1 may be used to promote the circulation of air over the coolers. In a modified apparatus, the vessel 1 may be divided by a second horizontal partition into two chambers, from the upper of which the water is withdrawn by the pipes 3, the cooled water being returned to the lower chamber. Vertical trunks connecting the two chambers contain rotary pumps carried by the shafts which operate the air-circulating pumps. The pipes 3 may be replaced by a series of flattened pipes to promote the cooling.



No. 174,103. Pulley-tackle Apparatus.

Schat, A. P., 3, *Kanaalstraat, The Hague, Holland. July* 26, 1920, *No.* 22254. [*Classes* 78 (v) *and* 115.]

Consists in pulley tackle for lowering loads, such as ships' boats, in which the hauling part of the rope is wound upon a drum provided with automatic braking means and the pulley blocks are provided with means for frictionally braking the rope. The winding-drum brake may be loaded by means of a weighted lever, spring, or the like, or, as shown, the brake may be applied by the load.

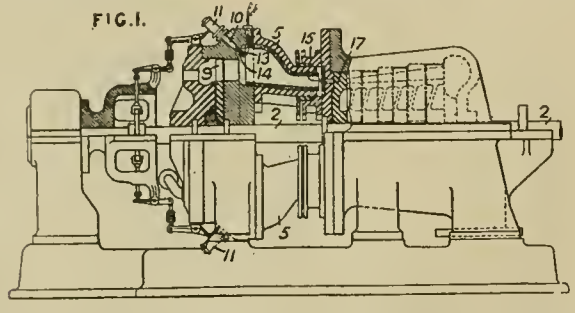


The boat 1 is suspended from the davit 2 by pulley tackle of the kind described in Specification 167,360 and comprising upper and lower blocks, the lower block *a* having a sliding spreading bar *b* arranged between the bights of the hauling rope 3 and the fixed rope 6. The bar *b* is hinged to a brake lever *e* carrying a brake block *g* adapted to act on the pulley or rope. The arrangement is such that the difference in tension of the ropes produced by the load releases the brake when hauling in and applies it when paying out, and in the latter case, in conjunction with the brake on the drum, holds the load suspended. The fixed rope 6 is connected to a lever 7 carrying a brake block acting on the drum 4 and is adjusted to exert the required braking force, which allows the load to be lowered by the release of the hand lever *e* by an operator in the boat, but sustains the load when the hand lever is actuated by the difference in tension in the ropes. Specifications 149,175, 154,470, and 168,970 also are referred to.

No. 174,179. Turbines.

Garland, J., Savoy Hotel, Funchal, Madeira. October 19, 1920, *No.* 29486. [*Class* 110 (iii).]

In an internal-combustion turbine, compressed air for scavenging and charging the stationary combustion chambers 5 is supplied

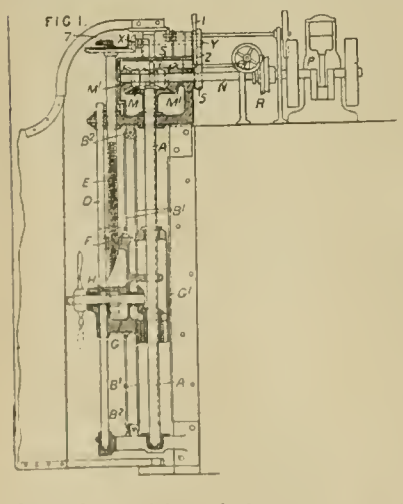


periodically through ports 9 in a disc secured to the turbine shaft 2. Fuel is injected through nozzles 10 controlled by cam-operated valves 11, and after ignition by an electrically-heated coil 13 in a recess 14 the gases are delivered to the turbine nozzles 15 which are periodically uncovered by a ported disc 17 secured to the turbine shaft.

No. 174,266. Propelling Ships.

Crossley, J. E., 36, *Carlton Terrace, Elland Road; Cockin, V. B. B.*, 109, *West Lillands; and Cockin, D. H.*, 14, *Woodhouse Lane, all in Brighouse, Yorkshire. December* 11, 1920 *No.* 33499. [*Class* 114.]

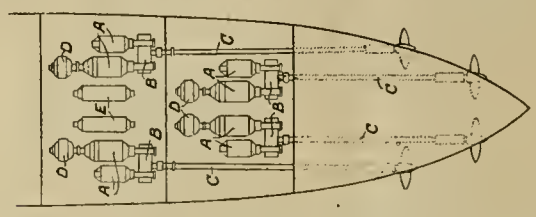
In propelling apparatus in which the propeller and shaft are adjustable in depth of immersion, the bracket carrying the shaft is counterbalanced and the change in position is effected by coupling the actuating gear to the main power shaft. A depth-indicator is provided. The propeller shaft H is mounted in a casing G, through which passes the splined driving shaft A. The casing is guided by rods D and a slipper G^1, and has a nut F, through which passes the depth-adjusting screw E. The weight of the casing is balanced by a strap B^1 passing over pulleys B^2. The screwed shaft is adapted to be actuated by bevel gears X and shaft Y. A pinion on the shaft Y is adapted to be geared to a pinion 5 on the power shaft N, when an intermediate pinion 2 carried by a pivoted arm 1 is swung into engagement. An indicator 7 is geared to show the position of the screw propeller. The driving bevel M on the vertical splined shaft A gears with loose bevels M^1 on the power shaft, which are coupled for forward or reverse running by clutches S to the power shaft N, which is itself connected to the engine P by a clutch R.



No. 174,315. Propelling Ships.

Soc. Anon. des Forges et Chantiers de la Méditerranée, 25, *Boulevard Malesherbes, Paris, and Cacaud, M. J. B.*, 6, *Avenue Pauban, Toulon, France. April* 22, 1921, *No.* 11670. *Convention date, January* 21. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 110 (iii) *and* 114.]

Plant for ship propulsion comprises turbines geared to the propeller shaft for high-speed propulsion and electromotors coupled direct to the forward end of the turbine shaft or geared to the turbine gears for cruising speeds and reversing at which times the turbines are idly revolved. The generator set for the electromotor may be that used for driving the auxiliary machinery of the main turbines or a separate generator may be provided. The turbine

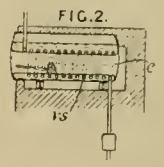


of the generator set may have reversing blades or reversal is obtained by controls in the electrical portion of the plant. A separate plant is provided for the port and starboard installations. Turbines A drive shafts C through gearing B, and electromotors D are directly coupled to the turbines. Auxiliary turbines drive the electric generator groups E, and supply the motors D for cruising, whilst at high speeds they supply power for the auxiliaries of the main turbines. When changing from cruising to full speed, the main turbines are started, and as they pick up the motors D are brought into synchronism and their power will diminish, thereby permitting the generators to be switched on to the auxiliaries and allowing the motors to be cut out.

No. 174,351. Steam Generators.

Ruths, J., Djursholm, Sweden, and Frenne, N. H., Stockholm. January 18, 1922, *No.* 1593. *Convention date, January* 21, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 123 (ii).]

Steam is generated in pipe coils immersed in, or in the vapour of a highly heated medium such as molten metal, sulphur oil, or a salt solution. Water is pumped into a coil VS around the flue *e* of a Cornish boiler containing the highly heated medium. Flat coils may be suspended in a boiler above the level of the medium therein. The pump may draw the water from an economiser. Zinc, lead, aluminium, fusible metal alloy, oil, sulphur, or salt solution may be used as the medium.



ENGAGEMENTS FOR APRIL.

Institution of Naval Architects.—Meetings in Lecture Hall of the Royal United Service Institution, Whitehall, London, S.W., Wednesday, April 5, Thursday, April 6, and Friday, April 7.—Evening Reception by the President, His Grace the Duke of Northumberland, on Tuesday, April 4, in the Naval Museum of the Royal United Service Institution, at 9 p.m.—Wednesday, April 5, Annual Dinner in Grand Hall of the Connaught Rooms, at 7.30 p.m.

Institution of Automobile Engineers.—Meeting at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, Westminster, S.W., at 8 p.m., Wednesday, April 12, "Marine Engine Design as Affected by Lifeboat Service Conditions," by A. F. Evans.

Institute of Marine Engineers.—Conversazione, Hotel Victoria, Northumberland Avenue, London, W.C., at 6 p.m., Tuesday, April 21. Reception by Sir Joseph Maclay (President) and Lady Maclay.—Friday, April 28, Annual Meeting at the Institute, the Minories, Tower Hill, London, E., at 6 p.m.—Tuesday, Wednesday, Thursday, Friday, May 2-5, Student Graduates' Examination.

Institute of Transport.—Meeting at the Institution of Civil Engineers, Great George Street, Westminster, S.W., at 5.30 p.m., Monday, April 10, "The Relation of Civil Engineering to Transport Problems," by Sir Alexander Gibb, G.B.E., C.B. (Member).

The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION CARGO HANDLING APPLIANCES

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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On the occasion of his retirement, Mr. E. W. Stephenson, Commodore-Engineer of the Elder Dempster fleet, on April 20 received a handsome mahogany clock subscribed for and presented by the marine engineers of the Elder Dempster Line. Mr. Stephenson spent 41 years in the service of the company, having joined the African Steamship Company in 1880 as fourth engineer, and in 1886 he was promoted to chief engineer.

Mr. W. Waddell, M.Inst.C.E., has been appointed as Docks Assistant to the Chief Engineer for the South Wales ports. Mr. Waddell has been connected with the Barry Docks undertaking since its inception, having been on the staff of Sir John Wolfe Barry, the consulting engineer for the construction of the Barry railway and docks. He acted as the Barry Company's chief engineer from 1903 to 1919, when he was appointed general manager.

Mr. W. R. G. Whiting, M.A., M.B.E., who has been awarded the Institution of Naval Architects' Premium for 1921, for his paper on "The Strength of Submarine Vessels," has previously contributed to the Proceedings of the Institution. He was born in 1884, and educated at Mill Hill School and Cambridge University. He commenced his career at Armstrong's Elswick shipyard, under the late Sir George Carter. Mr. Whiting had charge of Professor Welch's technical staff on the *Titanic* Commission, and on the completion of this returned to the Elswick works. During the war he had charge of the construction and repairs of submarines, and was awarded the M.B.E. for his services. Mr. Whiting is now personal assistant to the general manager of the Armstrong and Walker shipyards of Sir W. G. Armstrong, Whitworth & Co. Limited.

Mr. C. B. Nichols has retired from the position of Principal Surveyor in Liverpool of the British Corporation Registry of Shipping, which he has held for 23 years. He was educated at Bunbury Aldersey School, and served his apprenticeship with Laird Bros., passing through the shops and drawing office. His first sea job was in Lord Brassey's famous yacht *Sunbeam*, and his remaining sea service was served in vessels of Alfred Holt & Co. On leaving the sea he first joined the staff of Robert Napier & Sons, Glasgow, and later that of Sir Edward Reed, K.C.B., who was consulting naval architect for the India Office and the Crown Agents for the Colonies. Mr. Nichols joined the staff of the British Corporation in Glasgow in 1897 and went to Liverpool to take up the position of principal surveyor in 1889. On his retirement Mr. J. Foster King, Chief Surveyor, presented Mr. Nichols, on behalf of the staff, with a travelling bag and wrist watch, and spoke very highly of his services and of the esteem in which he is universally held.

Mr. Fred. F. Perris, M.I.N.A., who has succeeded Mr. C. B. Nichols as Principal Surveyor at Liverpool for the British Corporation, was born near Liverpool and educated at the Botler Grammar School, Warrington, and King Edward VI School, Norwich. He commenced his apprenticeship in 1882 with R. & J. Evans & Co., Brunswick Dock, Liverpool, transferring in 1887 to Earle's Shipbuilding & Engineering Company, Hull. Mr. Perris was Assistant Manager to R. Craggs & Sons, and to Leslie & Co., Hebburn-on-Tyne, before being appointed a Surveyor to the British Corporation, Glasgow, in 1895, and in 1897 went to Sunderland as Senior Ship Surveyor on their N.E. Coast staff. In 1907 he was appointed Principal Surveyor of the Tees district. In 1920 he went out to Japan as the Registry's adviser to the Japanese Corporation, visiting the various Canadian shipbuilding centres on his journey out and some of the principal Eastern ports on his return.

Mr. John Herbert Vickery, J.P., General Manager of the Alexandra (Newport and South Wales) Docks & Railway Company, has been appointed Chief Docks Manager of the railway docks included in the Great Western Railway group under the amalgamation of the South Wales Docks and Railways. Mr. Vickery, whose headquarters will be at Cardiff, has gained his experience in the course of a varied career with the London & South Western Railway Company. Beginning as a junior clerk in the goods manager's department, where he served for eight years in various capacities, he was appointed Secretary to the Superintendent of the Line, and subsequently became head of various departments, ultimately becoming, before the age of 30, Chief Clerk in succession to Mr. (now Sir) Sam Fay. Five years later the late Sir Charles Scotter appointed him to the responsible post of London Divisional Superintendent, and a few years later he was promoted to be Assistant Superintendent of the Line. He was subsequently invited by Sir Charles Owens, then General Manager, to become his assistant, in which capacity he served for several years. Early in 1913 he was selected to succeed Mr. John Macaulay as General Manager to the Alexandra (Newport and South Wales) Docks and Railway Company. Mr. Vickery took up his new position on May 1.

EDITORIAL.

ENGINEERING AND TRADE DIFFICULTIES.

In our January issue we reviewed the position of the marine engineering industry as it then stood, and the outputs of 11 engineering firms in Great Britain were tabulated as showing the great variety of types of engine under construction during the year 1921. As demonstrating this variety the table submitted contained the names of those engineering establishments devoted exclusively to the manufacture of machinery, no account being taken of concerns devoted to the construction of hulls and machinery. It was shown that the reciprocating steam engine still occupied a strong place in the industry; that the geared turbine was distinctly increasing in popularity; and that the Diesel engine was rapidly developing on sound lines. The developments in the field of auxiliary machinery as distinct from main propelling machinery were shown to be even greater and more varied, and the need for close scrutiny on the part of shipowners' technical advisers to ensure that ships should be built and operated on a strictly economic basis was emphasised.

It is now common knowledge that the majority of British marine engineering establishments of any magnitude are capable of, and equipped for, the manufacture of steam reciprocating, geared turbine, and Diesel engines. Here, then, we have ample evidence of the adaptability and enterprise of our captains of industry. Moreover, it has been amply demonstrated that our artisans and shipwrights can produce work which, as to all-round excellence, is favourably comparable with that produced in any other country in the world. The present depression is world-wide, and is not confined to this country, but the fact should not be overlooked that in the face of increasing foreign competition we cannot afford to rely on past achievements as constituting a basis for our hopes of future prosperity. An infinite variety of explanations has been submitted for the universal industrial depression existing at present, and these may safely and in general, be ascribed to circumstances almost totally outside our immediate control. Not so when we turn to the relations existing between capital and labour to-day. We have gradually come to accept the severely attenuated order list for new tonnage as a matter of fact, consoling ourselves with the knowledge that such was a world condition, and with the belief that the revival would at least bring us our fair share. We cannot, however, similarly accept as inevitable the transport of unfinished tonnage from this to foreign countries for completion. With a full knowledge of all the facts and after a careful review of every aspect of the controversy we fail to find anything in the state of the shipbuilding industry to justify the present policy of labour—a policy which, apart from the immediate loss of wages in work transferred elsewhere, must inevitably, if pursued, result in new work being placed in countries other than our own where a greater appreciation of the community of interest of employer and employed has been arrived at.

It has been said that figures may be made to prove anything, but we feel that no conscientious student of shipbuilding statistics can peruse without grave concern the statistics compiled by Lloyd's Register of Shipping covering the quarter ended March 31 last. Excluding 617,000 tons upon which work has been suspended, without regard to the present industrial troubles, the total tonnage under construction in the British Isles amounts to 1,619,000 tons. The corresponding figures 18 months ago were 3,750,000 tons. A comparison of war-time or post-war statistics with present-day returns cannot do other than engender misleading conclusions, and for purposes of fair comparison pre-war figures must be taken. During the 12 months immediately preceding the war the average tonnage under construction was 1,890,000 tons, *i.e.*, 271,000 tons more than the present-day figures. These statistics, it may be argued, are not, *per se*, sufficient to cause feelings of immediate misgivings, but, taken in conjunction with the insignificant amount of new tonnage laid down, they serve to reveal a prospect which anyone who has the future prosperity of the industry at heart cannot view without feelings of the gravest concern.

We feel that nothing could be better calculated to demonstrate the unwisdom of the present policy of labour than a tour round the great shipbuilding and engineering centres of this country just now, and if this itinerary were made to include the North-East Coast, Barrow, the Mersey, and the Clyde districts, we believe it to be totally impossible for the most impartial observer to arrive at any conclusion other than that the present policy is, in effect, tantamount to industrial suicide. Such is the range and varied scope of the work usually undertaken on the Clyde that the conditions obtaining at any given time may reasonably be taken as an accurate reading of the industrial barometer. To have sailed from the Broomielaw to the Cloch Lighthouse in pre-war shipbuilding days—we advisedly exclude the boom periods of war and post-war days, since booms precede and are only less desirable than slumps—was to see fitting-out and building berths well filled. The noise and the spectacle were at once a tonic and a source of pride in the health of a splendid industry. To-day these self-same berths are almost in a state of nudity; a few of the fitting-out berths are occupied by vessels on which the only work being effected is undertaken by apprentices; an oppressive silence prevails, engine and boiler shops are well-nigh empty, sinister, discontented workmen congest the streets—what was once a hive of activity is now an industrial sepulchre.

In this country we have finely-equipped yards and shops, we have first-class workmen, and we have a tolerable reputation for mental balance and industrial sanity. It is important that these essential factors should not be dissipated and lost, but should at once be marshalled and co-ordinated in preparation for the greater or lesser trade revival which sooner or later will assuredly come. Our shipowners are hard-headed men, and they extract no pleasure from diverting new tonnage for completion and operating tonnage for repair to foreign workmen. These are hard facts and neither masters nor men can afford to ignore them. A return to industrial sanity is the fundamental necessity of to-day, and without this there can be neither trade revival nor industrial prosperity in this country.

NON-CORRODIBLE IRON AND STEEL.

A PAPER of great importance to marine engineering, "Corrosion of Ferrous Metals," was read a short time ago before the Institution of Civil Engineers by Sir Robert Hadfield. In 1916 the Institution formed a Committee to study the corrosive action of sea water on structures in general, and Sir Robert Hadfield was consulted as to the best methods of investigating the results in connection with the ferrous metals. Acting upon his advice, 14 types of ferrous material, both iron and steel, were examined, the former consisting of wrought iron, Swedish charcoal iron, "Armco" iron, cold-blast cast iron, and hot-blast cast iron. The steel specimens selected were mild steel with low manganese and high sulphur and phosphorus content, mild steel with 0·7 per cent. manganese, medium carbon steel with low sulphur and phosphorus, carbon steel with 0·4 per cent. carbon, mild steel with 0·5 per cent. copper, mild steel with 2 per cent. copper, nickel steel with 3·5 per cent. nickel, nickel steel with 36 per cent. nickel, and rustless chromium steel (13½ per cent. chromium). The Committee fixed a standard size, 24 in. long, 3 in. wide, and ½ in. thick, for the

samples, and in the course of the investigations 1,330 separate specimens have been prepared, mostly in the "as rolled" condition, but in many cases also heat treated. An elaborate series of investigations as to the properties of 182 of the test pieces have been carried out in Sir Robert Hadfield's laboratory, including complete chemical analysis, Brinell hardness number, photomicrographs of longitudinal and transverse sections, tensile tests, and shock tests. Sets of the test bars are then to be immersed in the sea for a long period, at the end of which they will be examined in the same exhaustive manner to ascertain the extent of the corrosion and the difference caused in the various properties.

A remarkable feature of research work on alloys is the effect that even traces of one metal will have in altering the properties of the final alloy. Thus, for example, in connection with the corrosion of ferrous metals by sea water, the addition to steel of small amounts of copper causes a prononnced difference by increasing the resistance to corrosion, a fact for which there does not seem to be any adequate explanation.

Sufficient work has, however, been done of the subject of alloys in the last few years to warrant the expectation that we shall in the near future be able to produce non-corrosive iron, steel and other metals at a price capable of being used in bulk. It is difficult to realise what the corrosion of metals is costing the world, not only in damage and loss in the actual metal, but also in the continual costly painting that is necessary, and the shipping industry suffers more in this respect than any other.

Sir Robert Hadfield gives some arresting figures in his paper. It is estimated that the total steel production of the world from 1860 to 1920 has been 1,860,000,000 tons, of which about 660,000,000 tons have been destroyed by rusting whilst actually in use. In the year 1920, for example, the loss throughout the world was about 29,000,000 tons, and, taking the value of steel as, say, £20 per ton, the total loss to the world, including all the money spent on paint-work or other protective devices, was about £700,000,000. If ships can be made of non-corrodible metal throughout, it will be a revolution in marine engineering, the beneficial effect of which it is difficult to realise.

STEAM METERS.

THE paper by Mr. John L. Hodgson, "The Metering of Steam," which included a detailed description of the "Kent" steam meter, read at the Spring Meetings of the Institution of Naval Architects, draws attention to the fact that one of the most neglected sources of fuel economy, both in marine and land practice, at the present time is that of the proper utilisation of the steam meter. Even on land it will be no exaggeration to say that 95 per cent. of the factories of Great Britain have no steam meters. In practically every industrial establishment there are a certain number of general but distinct uses for which steam is required, such as the main engines, electric lighting plant, pumps for main water supply, steam nozzles of mechanical stokers, and the boiling of liquids, in addition, of course, to specific uses in various industries. The proper scientific method of management is to install steam meters on the main steam pipes for these various uses, and in this way to keep a record of the exact amount of steam taken, and so be able to adopt a proper system of costing.

The steam meter has, however, been neglected in marine practice even more than on land. In view of the importance of the subject it will not be without interest to give a brief account of the essentials of the metering of steam. It is perhaps only fair to say that one of the reasons why steam meters have not been used extensively is because only within recent years have they become a practical proposition. The invention of a reliable and accurate steam meter has, in fact, been one of the most difficult problems in engineering, especially because of the fluctuating nature of the average steam demand, the presence of varying amounts of moisture from almost zero to 5 per cent. in ordinary non-superheated steam, the pressure variation, and the violent swirling motion of the steam in the pipe. However, these difficulties have been largely overcome, and there are now on the market seven different makes of steam meter, which can be used equally well on land and sea.

In the Bayer and the St. John meters all the steam passes bodily through the casing of the meter, and lifts a tapered plug or a disc off its seat. The amount of lift is proportional to the amount of steam passing, and the plug or disc is connected to a pen mechanism which gives a continuous record of the steam.

The British Thomson-Houston, Curnon, and Sarco meters depend on the Pitot tube principle, and there is inserted between the steam pipe flanges a disc containing two tubes, one facing the flow of steam and one against. The slight difference in pressure up to, say, $\frac{3}{4}$ lb. per sq. in., is proportional to the amount of steam passing. The Bailey and the Kent meters are on the Venturi tube principle, that is, the insertion between the steam pipe flanges of a plain disc of less diameter than the steam pipe. At the constriction the pressure is slightly reduced because of the increased velocity of the steam, and this amount, say, up to $\frac{3}{4}$ lb. per sq. in. as before, is proportional to the amount of steam passing. The discs in both types of meter are connected to measuring devices, which record the pressure difference direct as pounds of steam passing in the pipe.

These measuring or recording devices belong to one of three distinct methods, the sealed bell, the diaphragm, and the U tube, the slight difference in the steam pressure causing an alteration either in the height of a bell floating in mercury, the position of a flexible diaphragm, or the level of the liquid in a U tube, and these differences actuate the pen mechanism.

Generally speaking, steam meters are accurate to 1 to 2 per cent. on steady loads, and certainly to 5 per cent. on fluctuating or pulsating loads, and it will be no exaggeration to say that at least 3 to 5 per cent. of the coal bill can be saved, whether in land or marine practice, by the adoption of the efficient steam costing system made possible by the use of these meters.

New Type of Stoker for Steamers.

Demonstrations were given in Glasgow last month of a new type of chain grate stoker, fitted to a Scotch boiler of the marine type. One of the features of the appliance, it is claimed, is that not only are the ashes not touched by hand but the fireman does not require to set any mechanism in motion. The machine itself discharges the ashes without attention, at such long or short intervals as may be required. The coal is fed into a hopper at the front of the boiler. Beneath the hopper there is a travelling grate, which carries the coal into the furnace, the thickness of the layer of fuel being regulated by a sliding door, as in some of the best-known stokers of the ordinary type. When, however, the fuel has become thoroughly burned, and has reached the rear of the furnace, instead of being carried over the back of the grate, it is arrested by heavy scrapers, which cause it to accumulate in a small pile across the entire width of the grate. At intervals, which may be regulated to suit the nature of the fuel, a section of the upper run of the grate (which is travelling inwards) falls open immediately under the accumulated ashes, causing them to be deposited on the lower run of the grate (which is travelling outwards), and in this manner the ashes are carried to the front of the boiler. On their arrival at the front, a section of the lower run falls open, and the ashes are discharged outwith the furnace. Immediately after any section of the grate opens it automatically re-closes, so forming a continuous moving grate.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Cloakrooms, Washing Facilities, Drinking Water and Sanitary Accommodation in Factories and Workshops. Welfare Pamphlet No. 8. Issued by the Home Office. 9½ in. × 6 in. Price 1s.

The purpose of this pamphlet is to supply information to employers as to the manner in which arrangements can best be made for the health, comfort and convenience of industrial workers, in regard to these subjects. Each of these subjects has been dealt with separately, the essential points indicated and suggestions made, based on the experience of the factory inspectors, as to how these points can best be met.

Il Costruttore Navale e la Geometria Della Nave. By Giuseppe Rossi. Milan: Ulrico Hoepli, Editore-Libraio della Real Casa. 1,120 pages, 859 illustrations and 76 tables. 6 in. × 4½ in. × 2 in. Price 42 lire.

This is a very comprehensive book dealing with every phase of the science of ship construction. The subject matter is divided up into a number of sections each dealing with one particular branch of naval architecture, such as the determination of ship form, method of construction, details of construction of the different parts, shipyard equipment, &c. Thus the work may be said to deal with both the theoretical and the practical side of the subject. The book is profusely illustrated, both with line drawings and reproductions from photographs, and a large number of tables are included. The value of the book is considerably enhanced by the inclusion at the foot of each page of a list of the names of the various parts discussed, given in Italian, French and English. If we say that this book resembles an enlarged edition of Mackrow's pocket book, an idea of its comprehensive nature will be obtained.

Modern Workshop Practice. By Ernest Pullen, A.M.I.M.E. London: Crosby, Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill, E.C.4. 671 pages, with 542 illustrations, 10 plates and numerous tables. 8½ in. × 6 in. × 2 in. Price 16s. net.

From small beginnings this book, which is now in its sixth edition, has rapidly become one of the most comprehensive works which has so far been published on the subject of engineering workshop practice. And yet while the scope of the book has been extended so as to include as far as possible every phase of the work which is done in a modern engineering shop, there are still one or two important branches which are hardly touched upon. Among these mention may be made of welding and the use of light tools operated by compressed air. Still, the work is sufficiently comprehensive to render it of particular value to marine engineers who, possibly more than any other branch of engineers, are called upon to undertake work of almost every kind that may be done in an engineering workshop. Moreover, the marine engineer must be able to do the work often with the scantiest of tools and with only the meagre equipment provided by the small workshop installed on board his ship. Every branch of fitting and of machinery is considered at great length, and such chapters as those on materials, workshop tools, heat treatment and forging, will have a particular value to the marine engineer who is called upon to exercise considerable judgment in regard to procedure with almost every repair job he performs.

The numerous tables of weights, proportions, &c., which are included in the book will also add to its value, while the very complete index containing over 1,500 references should greatly facilitate the finding of information relating to any particular job which the reader may have on hand. Mr. Pullen is to be congratulated on having provided a work which, with every succeeding edition, becomes more and more indispensable to the marine engineer. This book should form a part of that small library which every marine engineer takes with him when he goes to sea.

TRADE PUBLICATIONS.

Chapman-Hunter Pitchometer.—With this instrument it is claimed that the pitch of the largest propeller can be taken with accuracy and without calculation, therefore it saves time and labour. The instrument is easily portable and can be efficiently applied with the propeller in any position, either in the shop or on the shaft. The maker is Mr. James Hunter, 1, Dudley Avenue, Leith.

Paraffin Engines.—In view of the variety of purposes for which paraffin engines may be used as power units, the Parsons Motor Company Limited, Town Quay Works, Southampton, have published a book illustrating some of the uses to which the Parsons engine is adaptable, with a view to helping the prospective purchaser. A series of lay-out drawings are given which will be of particular interest to those concerned with power-station work.

Mechanical Stokers.—The chief merit claimed for this equipment is its constancy, the fuel and air supplies can be easily adjusted and need not be disturbed for long periods, the fuel bed is maintained at a suitable and economic thickness, and this method of stoking overcomes the smoke nuisance to a very large extent. Meldrums Limited, Timperley, Manchester, have published an illustrated booklet on their mechanical stokers, which work with or without forced draught, and claim that substantial savings can be made by its use. The publication describes their various types of stokers, fire bars, and coal elevators.

Electric Machinery for Marine and Industrial Installations.—Campbell & Isherwood Limited, Bootle, Lancs., have forwarded to us an instructive and well-illustrated catalogue showing their latest manufactures. These comprise, among others, electric generating sets up to 250 kw.; electric motors, d.c., or a.c., the former up to 200 h.p., and the latter up to 150 h.p., manufactured to a variety of designs, *e.g.*, open protected, enclosed ventilated, totally enclosed, &c.; electric cranes, capstans and winches; silent electric hoists for warehouse use; noiseless and machine-cut gearing, &c. The firm specialise in the planning and installing of complete schemes for electric light and power for all sizes and classes of vessels, industrial works or factories, cinemas, theatres, &c.

Small Turbo-Generator Unit.—The Westinghouse Electric & Manufacturing Company, of East Pittsburg, Pa., have recently placed upon the market a small turbine-driven dynamo having a capacity of only 500 watts at 33 volts. That is, the generator would be capable of supplying current to about 12 to 15 lamps of 25 candle-power each. The unit, which is complete in every detail, has been developed primarily for lighting steam locomotives on railways, but it should be of considerable value on small steam yachts or on cargo vessels for lighting the engine room and stokehold in port when it is not desired to run the main dynamo. The turbine itself consists of a single wheel and is designed to run non-condensing, although the exhaust could, of course, be led to the condenser, giving increased output. The London offices of the American Westinghouse Company are at Westinghouse Buildings, 2, Norfolk Street, Strand, W.C.2.

CARGO BOAT MACHINERY.—II.

The Relationship between Lloyd's Nominal Horse-Power and the Actual Indicated Horse-Power of the Engines.

In the first article of this series* we discussed the use of the rule laid down by Lloyd's Register for the determination of the nominal horse-power of the engines, and discussed its relationship to the North East Coast Institute's Guidance Specification for Triple Expansion Engines for Cargo Vessels. It is now our intention to consider the actual cylinder dimensions, &c., and the indicated horse-power of the engine required under given conditions.

Tramp steamers may be said to belong to the class of boats whose service speed constant is less than that given by the rule, knots $\div \sqrt{\text{length between perpendiculars of ship}} = \cdot 5$, with a block coefficient of about ·77 to ·82, *i.e.* $\frac{V}{\sqrt{L}} = \cdot 5$.

with a referred M.P. = 30 lb., and the revolutions adopted when designing the machinery.

Steamship owners and their superintendents, on closely examining this table, will find that their steamers which comply with the service speed rule constant, and block coefficient, having engines in accordance with the table, will come under the heading of tramp steamers, as the revolutions will approximate to load trial conditions when fitted with a large diameter propeller, *i.e.*, pitch ratio about = 1·0.

Consider now Table III, compiled in accordance with the 1919 specification for cargo steamers.

In this table it will be noticed that no revolutions are less than 60 per minute, in accordance with present practice,

Table II.—1917 Rule.

Stroke.	36		39		42		45		48		51		54		57		60	
Cylinder Diameter.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
H.P.	19½	20½	21	22	22½	23½	24	25	25½	26½	27	28	28½	29½	30	31	31½	32½
M.P.	32	33½	34½	36	37	38½	39	41	41½	43	44	45½	46	48	49	50½	51½	53
L.P.	53	56	57	60	61	64	65	68	69	72	73	76	77	80	81	84	85	88
I.H.P.	905	1,010	1,090	1,210	1,305	1,435	1,540	1,690	1,790	1,950	2,075	2,250	2,360	2,550	2,675	2,870	3,000	3,220
Lloyd's N.H.P.	173	193	208	231	247	273	291	318	339	370	391	424	447	483	508	546	574	615

Note.—The I.H.P. is approximately = 5·24 L.N.H.P.

Cargo steamers belong to the class of boat whose service speed constant is not less than that given by the same rule = ·5, but with block coefficient of about ·72 to ·77.

Consider, firstly, the 1917 specification rules governing the size of the engines for cargo steamers.

Table II above sets forth the sizes of cylinders and stroke in general practice, with the approximate Lloyd's nominal horse-power, and indicated horse-power, calculated

* See *The Marine Engineer and Naval Architect*, February, 1922, page 67.

and with the referred M.P. increased to 32·8 lb. gives a smaller engine for a given indicated horse-power.

This increase of M.P. to 32·8 lb. necessitates a lesser number of expansions and probably less economy in coal consumption, and on comparing the particulars given in the table with the size of machinery in the ship when fulfilling the service speed constant with its attendant block coefficient, such vessels may be said to be cargo boats, the powering having been done on not quite so economic a basis

(*Continued on page* 210.)

Table III.—1919 Rule.

Stroke.	36		39		42		45		48		51		54		57		60	
Cylinder Diameter.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
H.P.	19½	20½	21	22	22½	23½	24	25	25½	26½	27	28	28½	29½	30	31	31½	32½
M.P.	32	33½	34½	36	37	38½	39	41	41½	43	44	45½	46	48	49	50½	51½	53
L.P.	53	56	57	60	61	64	65	68	69	72	73	76	77	80	81	84	85	88
I.H.P.	984	1,100	1,180	1,305	1,395	1,540	1,640	1,795	1,910	2,073	2,200	2,380	2,520	2,720	2,875	3,090	3,250	3,480
Lloyd's N.H.P.	173	193	208	231	247	273	291	318	339	370	391	424	447	483	508	546	574	615

Note.—The I.H.P. is approximately = 5·68 L.N.H.P.

N.B.—These values have been calculated by the slide rule but are sufficiently accurate for all practical purposes.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.—III.

By E. V. Telfer, B.Sc.

Turning now to the consideration of the vertical position of the centre of gravity of a vessel, examination soon reveals the hazard in attempting to set up a simple relation which would give this position with any appreciable degree of reliability. From the point of view of arithmetical accuracy it is very doubtful whether even a detailed calculation or an inclining experiment yield results which are correct to the nearest inch. In fact, if the error were only 1 in. in a depth of say 30 ft., the percentage error ·28 per cent. would be probably less than the likely error in the estimate of the displacement itself. As now any approximate formulæ have to be based upon the results of either of the above methods, there can be but little hope of meticulous accuracy from their application. However, some sort of approximation is necessary in the design stage, and in attempting to establish a formula, considerations of attainable accuracy clearly show the futility of a complicated and apparently comprehensive expression. Dealing first of all quite generally with the problem, let us consider three classes of vessel, the ordinary cargo steamer, the small passenger steamer, and the larger passenger steamer. Confining our attention to the light condition, we see that, broadly, two distinct factors influence the result, the weight and type of hull and the weight, type and position of engines. Considering these factors jointly we can say that the finer a vessel and the greater the number of decks, the higher will be the centre of gravity, and the more will this latter be raised for a given percentage and nature of deck erections. The smaller and therefore generally the finer a vessel at a given speed the larger will be the ratio of the engine weight to hull weight, and hence generally the engine weight will tend to lower the centre of gravity of the whole. This is especially the case in turbine-engined vessels and least marked in slow speed reciprocating-engined vessels. Reviewing the above types from these considerations we see that flush deck cargo vessels, although full, have slow-running reciprocating engines whose centres of gravity are high and hence produce a relatively high system c.g. The effect of deck erections will, however, be relatively small, owing first to their nature, and second to the fullness of the main hull. The smaller flush deck passenger steamer, due to the low position of its turbine (or high speed reciprocating) machinery will have a lower centre of gravity in spite of it fineness of form. The centre of gravity will, however, be more largely effected by deck erections than was the case with the cargo vessel. The larger passenger vessel, although slightly fuller than the smaller, will have its centre of gravity higher than the smaller vessel owing to the relatively greater number of decks. The effect of deck erections, because of the relatively heavier hull, will be generally less than in the case of the smaller vessel. Comparing the larger passenger vessel with the ordinary cargo vessel, it is to be expected that whilst the weight and low position of the engines in the former will generally tend to produce a relatively lower system centre of gravity than in the latter, yet the greater number of decks and nature of erections of the former will generally counterbalance this effect.

From these general considerations, admittedly superficial, it is possible to frame simple formulæ for the above types which are at least qualitatively if not quantitatively reliable. It is usual therefore to express the height above keel of the centre of gravity of the equipped ship as a ratio of the depth D to the uppermost continuous deck, the ratio being modified for type and extent of erections above this deck. Suitable formulæ for the respective types are as follows :—

(1) Cargo vessels ... ... $g = (\cdot 50 + \cdot 25e)$. D
(2) Large passenger vessels $g = (\cdot 48 + \cdot 30e)$. D
(3) Small passenger vessels $g = (\cdot 45 + \cdot 35e)$. D

where g is the centre of gravity above keel and e the percentage erections.

It is easily seen that these formulæ conform to the foregoing general considerations, but it is necessary to repeat that they produce only average values and should be used as qualitative guides rather than quantitative solutions.

Another and slightly more comprehensive method which may be used is to express the height to the centre of gravity as a ratio of a modified depth of hull which takes into account the extent and nature of deck erections and also the amount of sheer. If S_F and S_A are the forward and after sheers, t, E and κ the height, length and type coefficient of the deck erections, L the length of the ship between perpendiculars, then this modified depth D_m becomes—

$$D_m = D + \frac{S_F + S_A}{6} + \frac{\kappa . t . E}{L}.$$

The term $\frac{S_F + S_A}{6}$ or M, say, is the Board of Trade new expression for mean standard sheer, and equals (in feet) $\frac{1}{12}(\cdot 04\,L + 8)$ for vessels having erections.

For purposes of simplicity this expression may be considered as equal to $\frac{\cdot 06\,L}{12}$, which is actually the case when L = 400 ft. If now an $\frac{L}{D}$ ratio of 12 is assumed, this expression for mean sheer reduces to ·06 D. Further, writing $\frac{E}{L} = e$, the above expression for the modified depth becomes for the case of standard sheer—

$$D_m = D\left(1 + \frac{\cdot 06\,D}{D} + \frac{\kappa\, t\, e}{D}\right)$$
$$= D\left(1 \cdot 06 + \frac{\kappa\, t\, e}{D}\right).$$

The height to the centre of gravity is then given by $g = \kappa_1 D_m$, which in the general case becomes—

$$g = \kappa_1 D\left(1 + \frac{M}{D} + \frac{\kappa\, t\, e}{D}\right),$$

and in the case of standard sheer

$$g = \kappa_1 D\left(1 \cdot 06 + \frac{\kappa\, t\, e}{D}\right),$$

which is of the same form as the expression given in the first method. This agreement may be made use of to obtain approximate values of κ and κ_1 for each of the respective types considered. Assuming typical values of $\frac{t}{D}$ for each type and comparing the above expression with the particular coefficients in the first method, values of κ and κ_1 are obtained, and then assuming that these values very approximately hold good for other than standard sheers, the following formulæ are obtained :—

(1*a*.) Cargo vessels... ... $g = \cdot 17\,D\left(1 + \frac{M}{D} + \frac{2.t.e}{D}\right)$.

(2*a*.) Large passenger vessels $g = \cdot 45\,D\left(1 + \frac{M}{D} + \frac{4.t.e}{D}\right)$.

(3*a*.) Small passenger vessels $g = \cdot 43\,D\left(1 + \frac{M}{D} + \frac{3.t.e}{D}\right)$.

The apparent contradiction in the value of erection coefficients in the passenger vessels is brought about by the very different values of $\frac{t}{D}$ associated with the larger and smaller types respectively. In any case of course these values of κ and κ_1 are merely suggestive, but it is felt, however, that if values of κ and κ_1 are carefully plotted for each type for which data is available, κ_1 being plotted to a base of $\frac{\text{mean sheer}}{\text{depth}}$ ratio and for varying numbers of complete decks, and κ to a base of percentage erections, it is probable that the data will be in its most convenient and reliable form. It should be noted that with this method, data for two similar vessels are required to fix the values of the two unknowns κ and κ_1. The suggested values of κ and κ_1 include the effect of machinery. Whilst this is not as fundamental as one may wish, yet, as practically all inclining experiment data deals with the vessel in the equipped condition, this form of presentation is more or less inevitable.

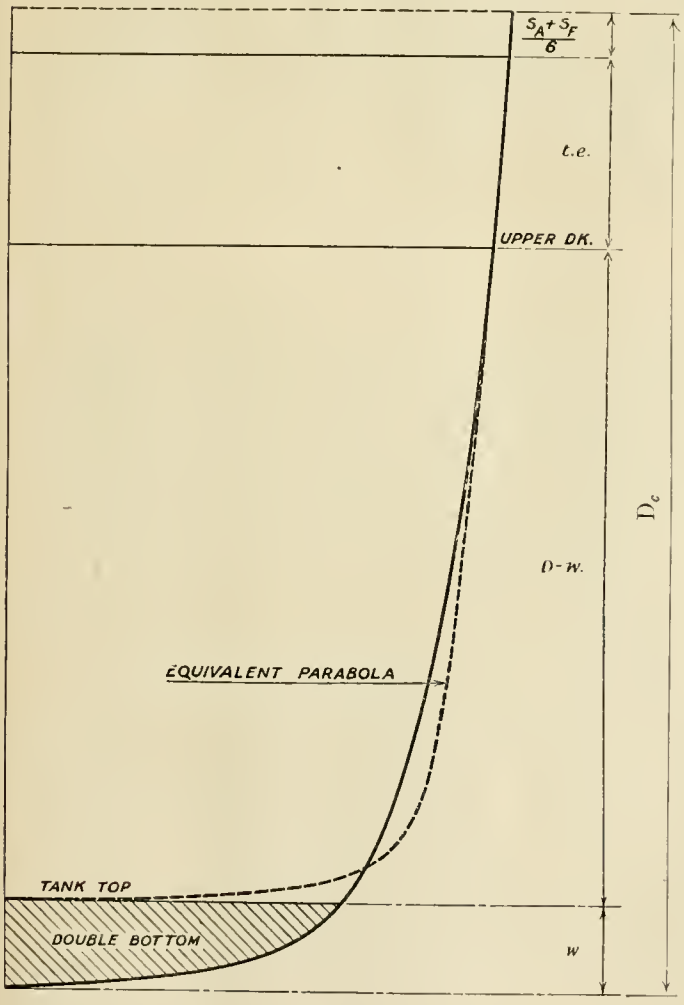


Fig. 10.

The foregoing methods will not obviate the necessity for a detailed calculation in a design where an accurate knowledge of the position of the centre of gravity is of importance, but they will certainly be of some assistance. At this point the question of the detailed calculation of the position of the centre of gravity might be well discussed. In this connection a very interesting contribution to the subject has been recently made by Herr W. Schmidt in the German shipbuilding journal "Werft, Reederei, Hafen." Where it has been the practice to carry out detailed estimates, Schmidt suggests that these should be carefully analysed. In each case the moment calculation should be repeated, taking the axis through the correct centre of gravity. This done, it will be very simple to single out those portions of the structure whose influence upon the position of the centre of gravity is greatest, and whose contrary effect will yield a very close approximation to the correct position. Schmidt further suggests that the weights should be classified in such a manner that their influence on the position of the centre of gravity would be immediately recognisable. For this purpose the structure is divided into three main classes :—

(1) Groups of important influence on the position of the c.g.

(2) Weights of a fairly constant proportionate nature, easy to determine, but of little influence on the position of the c.g.

(3) Weights not of a constant proportionate nature, not easy to determine, but also of little influence on the position of the c.g.

Each group can be then further subdivided, such as the hull into its constituent parts, and a comprehensive classification produced. Schmidt recommends the well-known Dewey classification, and thus each group such as hull, machinery, &c., receive numbers 1 to 9, each of their subdivisions are similarly classified, and finally the stage or nature of weight to which the calculation refers, such as design stage, completion of plans, invoiced weight basis, delivery, &c., is indicated in the same general manner. The complete classification of any item can be secured by this system; for instance, in the number 1411 the first digit represents the hull of the ship, the last digit represents the first item of this group, *i.e.*, the shell, the second digit gives the stage of the calculation, *i.e.*, in this case the delivery, and finally the third digit represents the fact that the item is of important influence upon the position of the c.g. The adoption of such a method as this is certainly to be recommended.

The final point to be considered is the effect of cargo upon the position of the centre of gravity. As is well known, the most critical practical case is when the holds are filled with homogeneous cargo of such density as will bring the vessel down to her load draught. The problem is analogous to that of the centre of buoyancy, and with some modification the formula given in that connection can be made use of. It is first necessary to examine the relation of the displacement dimensions to the cargo dimensions. The depth for cargo D_c, as is shown in Fig. 10, can be taken as the normal depth moulded, plus the 'tween deck height times the percentage erections, plus the mean sheer, *i.e.*, $\frac{S_F + S_A}{6}$. In vessels with double bottom the height of this must of course be subtracted from the above to obtain the corresponding cargo depth D in this case. The length for cargo L_c, say, will be the length of the ship less the engine and boiler spaces and also the peaks. L_c can be conveniently expressed as equal to $L\,(1-\lambda)$. The beam for cargo can be taken as equal to the displacement beam without much error. We can now write that the block coefficient for cargo equals

$$\frac{V_c}{L_c\,B.D_c} = \delta_c,$$

also the coefficient of fineness of the modified deck plane equals

$$\frac{A_c}{L_c\,B} = \alpha_c.$$

Now let V_d and A_d be the corresponding values of the volume displacement and total deck plane area respectively when immersed to this deck plane, *i.e.*, to a draught $D_c + w$, where w is the height of the double bottom. Therefore the block coefficient at this draught $D_c + w$, or $w\,D_c$, say, equals

$$\frac{V_d}{B.L.\ \omega\ D_c} = \delta$$

but $V_c = \frac{V_d}{\omega} - \lambda\ B.L.\ \omega\ D_c$ assuming, of course, in the first term on the right-hand side that the allowance for the volume of the double bottom is correctly represented by the factor ω, and in the second term that the 'midship section coefficient is unity. Therefore we have, dividing throughout by $B.L_c\ \omega\ D_c$.

$$\frac{V_c}{B.L_c\ \omega\ D_c} = \frac{V_d}{\omega\ B.L.\ (1-\lambda)\ \omega\ D_c} - \frac{\lambda\ B.L.\ \omega\ D_c}{B.L.\ (1-\lambda)\ \omega\ D_c}$$

$$= \frac{\hat{c}_c}{\omega} = \frac{\hat{c}}{\omega\ (1-\lambda)} - \frac{\lambda}{1-\lambda}.$$

$$\therefore \qquad \hat{c}_c = \frac{\delta - \omega\lambda}{1-\lambda}.$$

Similarly, $$A_c = A_d - \lambda\ B.L.$$

$\therefore$ Dividing throughout by $B.L_c$, we have

$$\frac{A_c}{B.L_c} = \frac{A\,d}{(1-\lambda)\,L.B.} - \frac{\lambda\,B.L}{(1-\lambda)\,L.B.}.$$

$$\therefore \qquad \alpha_c = \frac{\alpha}{1-\lambda} - \frac{\lambda}{1-\lambda} = \frac{\alpha-\lambda}{1-\lambda}.$$

Now for a parabolic distribution of volume we have seen that the height of the c.g. above base (in this case the tank top) is given by

$$\frac{D_c}{1+\frac{\delta_c}{\alpha_c}},$$

which equals, therefore, in terms of δ and α,

$$\frac{D_c}{1+\frac{\delta-\omega\lambda}{\alpha-\lambda}},$$

and this reduces, after rearrangement, to

$$\frac{D_c}{2-\frac{1-\frac{\delta}{\alpha}+\lambda\,(1-\omega)}{1-\frac{\lambda}{\alpha}}}.$$

Now as $\lambda\,(1-\omega)$ is generally numerically less than $-\cdot02$ and is thus unimportant, and moreover, if neglected entirely will tend to give too high an estimate of the position of the c.g., and is thus on the safe side, the above expression finally reduces to

$$\frac{D_c}{2-\frac{1-\frac{\delta}{\alpha}}{1-\frac{\lambda}{\alpha}}}.$$

The coefficients refer to those of the ship itself when immersed to the draught $\omega\,D_c$, but as $\frac{\delta}{\alpha}$ is nearly always constant from the load draught upwards, it is sufficiently near to consider $\frac{\delta}{\alpha}$ as fixed by the load waterplane, and then only the value of α, the coefficient of fineness of the deck plane, has to be obtained. In the first article of this series (January) it was shown that the waterplane coefficient could be expressed as a function of the draught as follows :—

$$\frac{\alpha}{\alpha_o} = \left(\frac{x}{d}\right)^n \text{ where } n = \frac{\alpha_o}{\delta_o} - 1,$$

α_o and $\hat{c}_o$ being the respective coefficients of waterplane area and displacement at the load draught d. From this formula the deck-plane coefficient can be obtained by substitution, thus

$$\alpha = \alpha_o\left(\frac{\omega\,D_c}{d}\right)^{\frac{\alpha_o}{\delta_o}-1}$$

This expression, and that for the centre of gravity of cargo, are rather too complicated for alignment chart treatment. The final expression for the centre of gravity of cargo becomes

$$g_1 = \omega + \frac{D_c}{2-\frac{1-\frac{\hat{c}}{\alpha}}{1-\frac{\lambda}{\alpha}}} \text{ feet above keel.}$$

We are now in a position to obtain the height of the centre of gravity of the vessel in the load condition. Let p be the light weight of the vessel and Δ the gross deadweight carried by it. We have therefore that the load position of the centre of gravity equals (see Fig. 1, January)

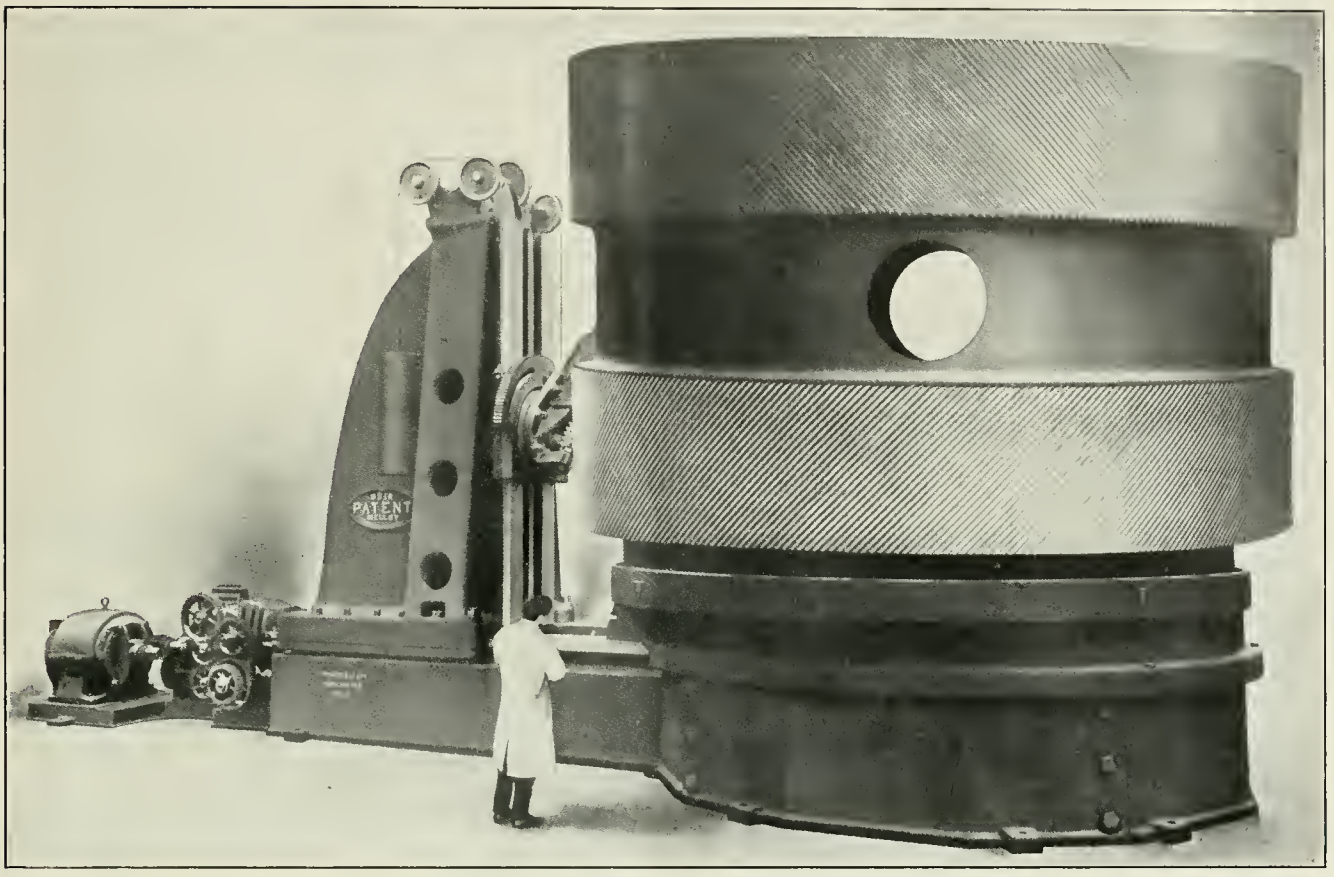
$$a + b = \frac{g.p + g_1\,\Delta}{p+\Delta} \text{ feet above keel.}$$

It is almost unnecessary to add that this centre of gravity of cargo investigation refers more particularly to pure cargo vessels. Where oil fuel is carried in the double bottom the above case of homogeneous cargo will be still the critical case and the tanks should be considered empty. For other cases where the centre of gravity of the bunkers is above that of the whole ship it may be necessary to investigate the influence of the bunkers. It is probably sufficient, however, to assume that the homogeneous loading whose density is generally somewhere about 50 to 55 cubic ft. per ton takes into account the bunker effect.

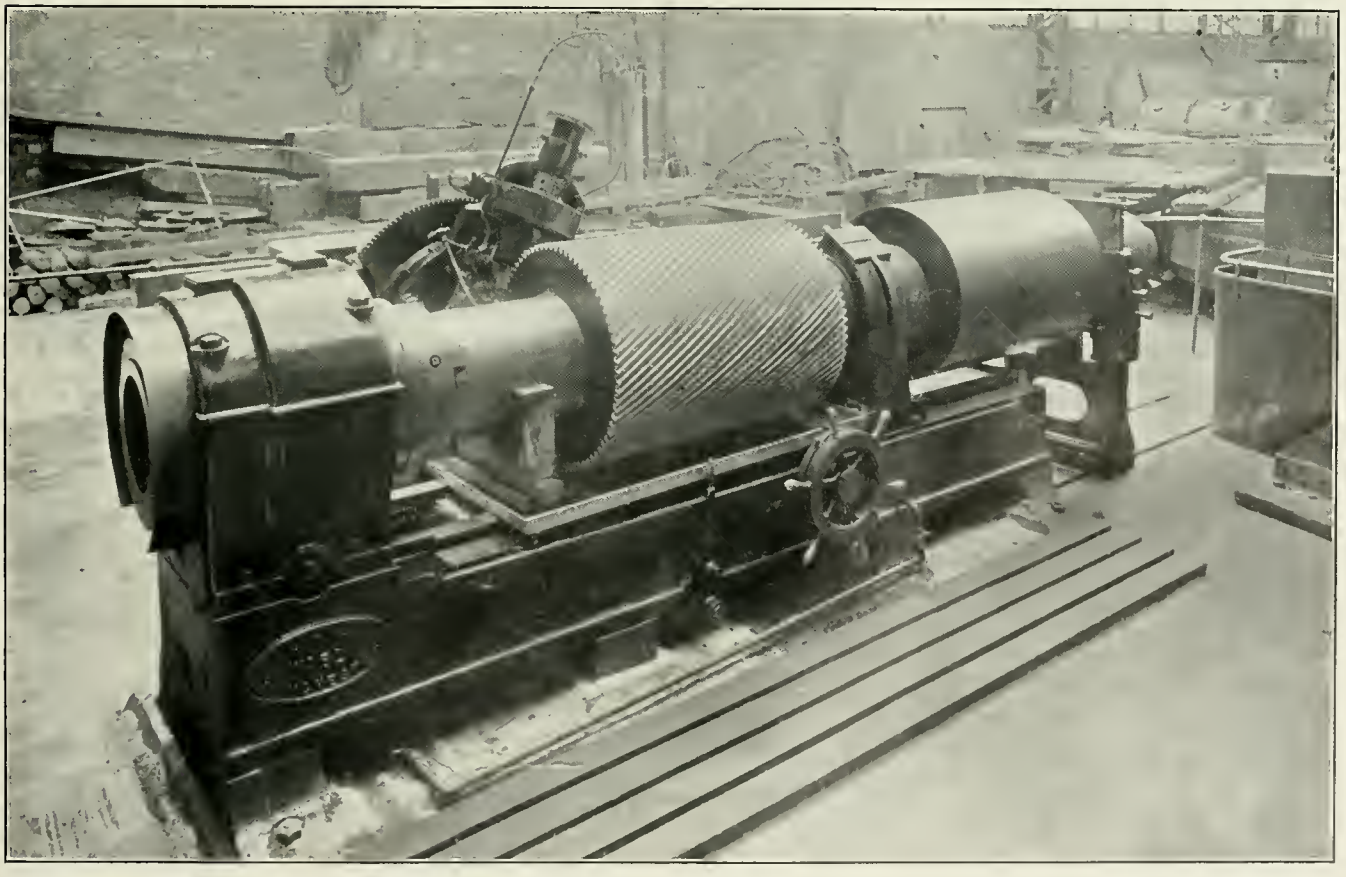
The estimation of the position of the final centre of gravity either by detailed or approximate methods as outlined above is always open to error. It is advisable, therefore, to allow a margin of at least three inches to cover oneself against possible inaccuracies.

We have now outlined methods whereby the three constituents of initial stability can be rapidly and more or less reliably estimated. In the subsequent and final article of this series the above methods will be applied to a definite case, and the possible extension to the more general problem of the provision of adequate stability at any given angle will be attempted.

Institution of Civil Engineers Awards.—The Council of the Institution of Civil Engineers have made the following awards for papers read and discussed during the session 1921-22 :—Telford medals to Sir Henry Fowler, K.B.E. (Derby), Mr. H. N. Gresley, C.B.E. (Doncaster), and Mr. H. F. Parshall. D.Sc. (London) ; a Watt medal to Mr. William Willox. M.A. (London) ; an Indian premium to Mr. F. G. Royal-Dawson (London) ; Telford premiums to Mr. A. W. Rendell (Bournemouth), Mr. W. F. Stanton, B.Sc. (Chile), and Mr. A. C. Walsh (Chile). The awards for papers printed without discussion in the " Proceedings " for this session will be announced in the autumn. The Council have also made the following awards for papers printed without discussion in the " Proceedings " for the session 1920-21 : A George Stephenson medal to Mr. J. H. Taylor (Buenos Ayres) ; Telford premiums to Mr. F. H. Hummel, M.Sc. (Belfast), Mr. E. J. Finnan, M.Sc. (Belfast), and Mr. Herbert Chatley, D.Sc. (China) ; and a Trevithick premium to Mr. G. E. Lillie, F.C.H. (Reigate).



Cutting a large Gear Wheel. Weight of Blank exceeded 50 tons.

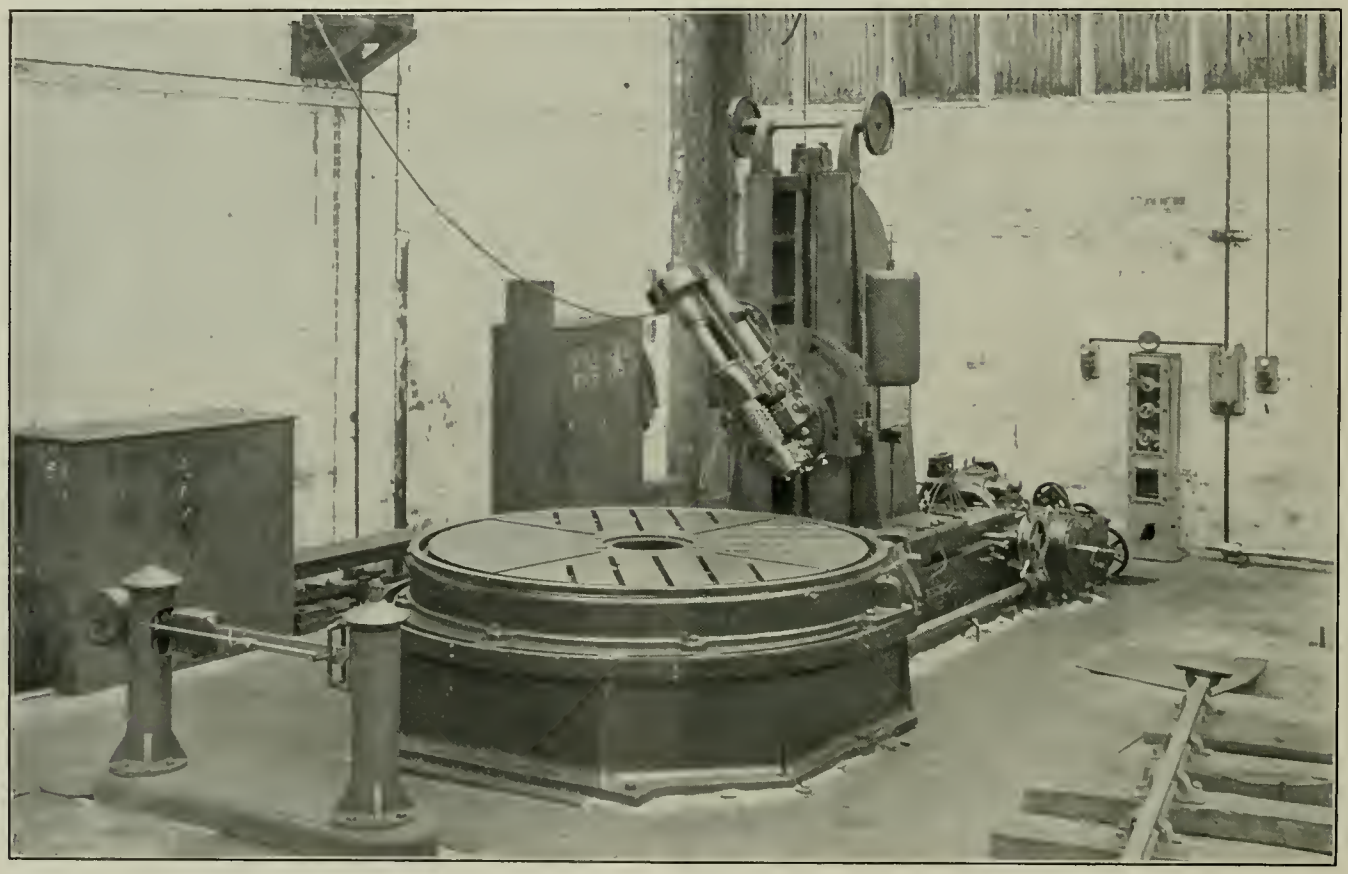


Hobbing Machine for cutting Pinions, by Wm. Muir & Co. Ltd. (*See page* 184.)

TURBINE REDUCTION GEARING AND ITS PRODUCTION.*

The Hobbing Process with Particular Reference to the Muir & Melloy Patent Hobbing Machine.

In the transmission of power by electric current over long distances, it is well known that comparatively small areas of conductors, and in consequence much less costly, can be used by applying a very high voltage; so in the mechanical transmission of power, comparatively small turbines, if run at a sufficiently high speed, can be made to transmit any required power. The high voltage referred to, to meet practical requirements, has to be transformed; so in the case of the turbine, the excessive R.P.M. has to be reduced to meet practical requirements. This reduction is the function of the gearing. It is obvious that the outstanding requirement of such gears is silent and smooth running. To achieve this result, great accuracy in the cutting of the teeth is required; it is also obvious that the more gradually the teeth come into contact, the smoother the running, hence the adoption of the helical type of tooth. Ratios of 25 to 1 can be obtained with single-reduction gears, but when greater reductions are called for a double-gear set is employed. Reductions of 50 to 1 can be obtained from double-geared sets.



The Muir & Melloy Patent Gear Hobbing Machine made by Wm. Muir & Co. Ltd.

The design of a machine tool to handle such work should meet the following requirements:-

(*a*) A dividing wheel of maximum diameter should be available to properly control the work—the larger the dividing wheel the better the results. The machine which the author's firm has developed for this purpose can efficiently deal with pinions 4 in. diam. up to wheels 12 ft. diam., by a system of interchangeable tables. A choice of three dividing wheels is available, in order to bring into use the largest dividing wheel possible. The drawing on the opposite page shows: (i) The machine cutting pinions; (ii) A wheel 2 ft. diam. being cut with a dividing wheel 5 ft. diam.; (iii) A wheel 5 ft. diam. being cut by a dividing wheel 8 ft. diam.; (iv) A wheel 12 ft. diam. being cut on the same table; thus covering a range of gears from 4 in. diam. to 12 ft. diam. on the same machine.

(*b*) A very accurate dividing wheel is imperative. An absolute accurate dividing wheel is not guaranteed, but its close approximation is assured. There is no practical tooth-to-tooth error. The slight accumulated error in groups of 20 teeth—some zero, some plus or minus—are well distributed round the circumference, an accuracy easily sufficient to produce the most silent and smooth-running gears.

(*c*) The mechanism controlling the spiral angle must be so arranged that the tooth angles of mating gears are automatically produced with the absolute identical angle, without recalculating or resetting the spiral change gears. Though all the mechanisms are under the control of a single drive and are interdependent, they may be considered as three motions having independent functions:—The hob motion, which can be varied through a differential mechanism; the table motion, which can be varied by the main dividing change wheels; and the down-traverse of the hob slide, varied by its feed gears.

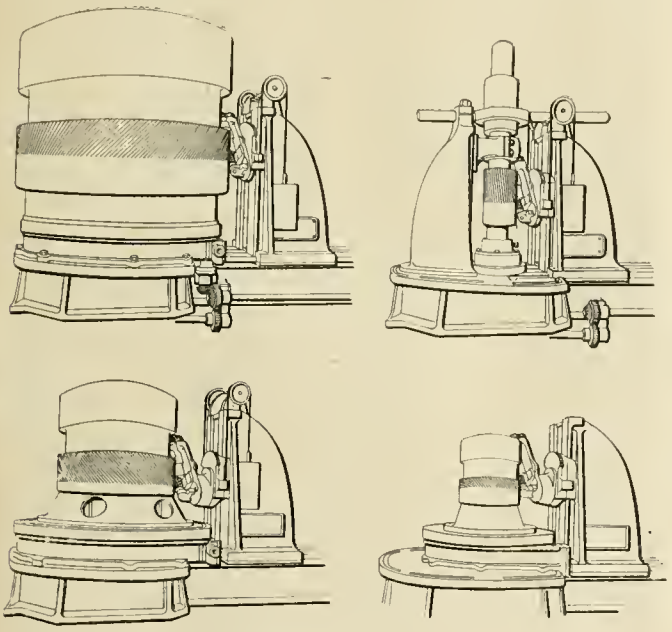
The elements of the mechanisms will be understood from the following notes and a reference to the diagrammatic

* Abstract of paper read by Mr. J. H. Melloy, Managing Director of Wm. Muir & Co. Ltd., Machine Tool Makers, Manchester, before the North Western Branch of the Institution of Mechanical Engineers.

lay-out shown in the drawing opposite. The hob motion: A is the hob driven through shaft D by change wheels E from the motor. Table motion: B is the dividing wheel driven by worm C through shaft R by change wheels G from motor. The gears E and G of course vary with the different numbers of teeth to be cut. Hob slide traverse: The feed screw L is controlled by shaft D through feed gears H (four changes), worm and wheel J and compensating gears K through shaft S. The shaft S also controls the accelerating or retarding of the hob through change gears M and differential gears N in order to produce the various right-hand and left-hand spiral angles in the teeth.

It will be noted that differential control of the spiral angles is the hob motion section. The spiral angle could be obtained by placing the differential gear in the table motion, shaft R, but this arrangement upsets the requirement (C), because change wheels have to be introduced, which sometimes preclude identical angles being obtained in the mating gears, thus affecting the continuous bedding of the teeth.

(*d*) In fast-running gears with heavy tooth pressures, the principle of the Hunting tooth should be adopted. This often



Different Sizes of Wheels which can be cut on the Muir & Melloy Gear Hobbing Machine.

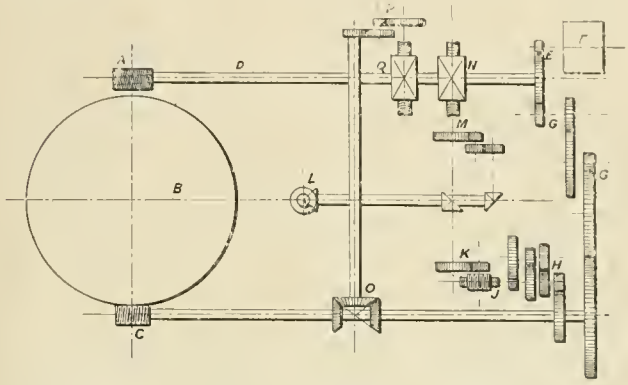
demands the introduction of a prime number in the teeth; consequently, a mechanism for automatically dividing for prime numbers is called for.

To meet this requirement, the author's firm developed and patented a prime number dividing mechanism, which is embodied in the gear box as follows:—From the table drive shaft R, through a reversing bevel drive and change wheels P, a supplementary differential gear Q is introduced into the hob drive D. By this means the change wheels P can add to or subtract 1, 2, 3, 4 or 5 from the number of teeth the gears G would produce.

(*e*) The machine, once started cutting, is often required to run night and day for two or three weeks without stopping, in order to eliminate casual variations. The design and arrangement of gears to meet this requirement has demanded the most careful consideration. They are of cut steel, hardened, running in lubricant in a box provided with inspection doors, carried at end of bed.

(*f*) As the work varies in weight from comparatively light pinions to gear blanks weighing 30 tons, the friction set up in rotation of the heavier gears has to be partially relieved to give a reasonably constant torque. To achieve this an easily-adjusted counterpoise is required. The balancing arrangement efficiently meets this requirement.

(*g*) The position of the worm controlling the dividing wheel, with regard to that of the hob, is important. If the work is placed at the opposite diameter to the job working through the dividing wheel, from the author's experience distortion is liable to set up. The work should be placed, if possible, vertically underneath the hob. By so doing, the distortion factor is entirely eliminated. Some makers put forward a dual work drive to the dividing wheel, but in that case there is a great question of them functioning simultaneously, and in any case the danger of distortion troubles still exists.

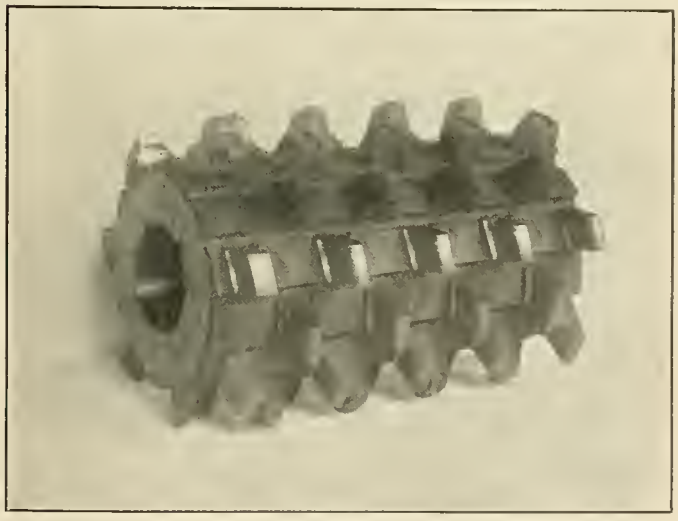


Diagrammatic Lay-out of Muir & Melloy Gear Hobbing Machine.

Description of Machine.

The general arrangement of the machine is shown in the illustration on the opposite page, from which it will be noted that the bed is of the banjo formation to accommodate the interchangeable tables. The circular end carries a massive hollow spindle on which the tables pivot.

The hole in the table spindle is 2 ft. diam., and as some



An Improved Form of Hob.

gear blanks are mounted on their shafts before the cutting operation, this permits the shafts to pass through the bed, bringing the blank into a convenient position on the table for cutting. The lower end of this hollow spindle rests on a footstep ball race carried on a fulcrumed weighbridge arrangement, to which is connected an outside steelyard arm, by which any counterpoise to the weight carried by the spindle up to 30 tons can be given and indicated by the floating steelyard.

To the other end of the bed is attached the gear box containing all the driving mechanism. These are all closed in and running in lubricant, distributed to the required parts by means of a pressure pump. This supply of lubricant is entirely separate from the cutting compound which is spread on the hob, which lubricant, after being used, passes through a sieve into a tank in the base, from there pumped into a reservoir as shown, giving a gravity feed supply to the hob.

Apart from the ability to run continuously for long periods, absolute rigidity is called for, especially in the large gears dealt with. The massive design of the upright will be noted. This can be run along the bed to or from the work by quick power. At the same time, by means of ball race bearings, it is easily adjusted by hand, that is, when dealing with the depth of cut. The hob is brought to touch the blank—the micrometer disc set to zero—then from this setting all information regarding the important question of the depth of tooth is clearly indicated.

The spindle slide carrying the hob is mounted on the face of the upright and is very carefully designed so as to give even motion without chatter. The guide for the down traverse has internal narrow angles for steady motion, and outside strips for stability. The down traverse referred to is under the control of a very accurate screw, which is equally important to that of the dividing wheel, because a combination of the two gives the angle of the tooth spiral, and any appreciable variation affects the even bedding of the teeth.

The thread of the hob tooth must always lie exactly in the line of the tooth space of the helix and may be either left or right hand, consequently the slide carrying the hob must be capable of swivelling to any angle on either side of the vertical. This is a most important setting, because any inaccuracy affects the width of space. For this purpose, the author's firm has developed a very efficient angle-finding clinometer, with which the hob can be set easily and accurately to one minute of a degree, giving the correct angle of the hob to the work, independent of the levels of the machine. It is provided with a calibrating spirit level by which a datum level can be taken from the work or bed. After this adjustment, the arm is moved through the required angle, the exact setting being under the control of a Vernier scale and adjusting screws. The instrument is then placed on the hob spindle, and the slide rotated till the spirit level is horizontal.

The Hob.

Experience has shown that the ordinary type of hob originally used in these machines fell very far short in producing the results demanded.

This led the author to develop the hob with the tooth formation as shown on page 185. It has alternate teeth removed, permitting the hob to be ground all over to ensure correctness of shape and pitch. Another feature of this type of hob is important. Due to its formation, the leading teeth can be given front rake so as to rout freely, thus reducing the strains referred to, and greatly increasing the resultant accuracy. In the author's opinion, the old type of hob had a redundancy of teeth, which led to burnishing rather than free cutting. The increase of distance between the cutting edges of the teeth in the hob gives the opportunity of a proper bite. At the same time the extra space is an advantage in clearance to carry away the chips. The teeth of the hob which generate the tooth curve can also be ground with side rake, which, in cutting some materials, is of great advantage.

The taper end of a hob for helical gears is at first glance apparently a paradox, and often leads to a blunder—the taper being at the back end as regards the head of thread and direction of rotation, that is, opposite to that of a hob for cutting worm wheels. Theoretically, a hob will cut either hand of spiral, but in practice, due to the accumulated wear in the main worm, slight errors are liable to enter—consequently, a right-hand hob for a right-hand spiral and left-hand hob for a left-hand spiral is imperative.

Important Factors in Good Production.

In the production of these gears there is more than one source from which errors can enter, consequently the ultimate good running of the same is the outcome of many important precautions.

The setting of the work is most important. Cutting should not be commenced till the surface of the blank is mounted truly concentric. Mounting of the work on a cradle is to be recommended, because bolts and cramps, passing directly through to the table, are liable to set up distortion. Further, by means of a tool box fixed on the spindle slide, the spotting surface of the cradles can be lightly skimmed up true to the rotation.

In preparing the blanks a spotting diameter should always be provided that is truly concentric to the axis of the blank, to fit which the cradle is prepared. The clock indicator at this point is a critical test of good turning, because if the sides and face are not square, or the blank oval, the fault will be shown up, and should be corrected, or it is risky to proceed. Foremen have been known to take days at this operation, but the splendid results have justified the trouble taken.

Another important factor that requires intelligent attention is wear in the main driving work. The material of the worm should abrade or wear rather than that of the dividing wheel itself. It is quite a simple matter to renew the worm and clear off all dividing troubles, but errors introduced into the dividing wheel are always present and can only be remedied by a replacement. The wear referred to is remarkably small during the process of cutting in one wheel, and has no measurable effect in the resulting tooth angle that would affect the continuous bedding of the teeth of the gears. As a matter of fact, after the first test wheel is cut the worm settles down, and the wear becomes normal, continuing in constant work cutting scores of large gears, and it is often a matter of two or three years before the accumulated error renders it necessary to replace the worm. A stand-by or replace worm should always be kept handy so that no time is wasted when the replacement is necessary.

To meet the requirements referred to in paragraph (*f*) above the machines are fitted with a weighbridge counterpoising arrangement, seen in the illustration on page 184, with which a counterbalance can be interposed to relieve the weight of the work. This is adjusted till the ammeter in circuit shows that about 5 b.h.p. is being absorbed in running the machine idle. This ensures that the table is rotating safely on its bed, but with a minimum known pressure to set up friction. The ammeter provides a good gauge that the operator can keep his eye upon to warn him of variations, and the handy adjustment of the steelyard balance enables him to compensate for any alterations that may be required.

Some gears are of a weight beyond the 30 tons capacity of the weighbridge arrangement that we provide. Such weights have to be dealt with as a special case. The upper illustration on page 183 shows a gear blank over 50 tons weight. This was obviously beyond the capacity of our counterpoise arrangement. The rig-up consists of a strongly-supported cross-girder, mounted on which is a fulcrum bracket carrying a massive lever. From one end the blank is suspended at its centre of rotation by means of a ball swivel. The other end carries a balance-weight which can be adjusted to give the usual resistance to rotation as shown by the ammeter.

As might be expected, gears of the great weight as that just referred to have the effect of upsetting the alignments of the machine by causing the foundations to link, thus upsetting another very important factor in the correct cutting of the gears. If, however, proper precautions are taken when a machine is first set down, the readjustment of the alignment of the machine is not a serious matter. When installing, before levelling, the bed should be balanced on a flat bar—say, 6 in. wide by 1 in. thick. This supports the centre of gravity of the machine. Wedges are then inserted all round to bring

the top surface of the bed level, and the whole grouted in. If anything arises to cause a readjustment necessary, the wedges are knocked out, the bed again balances on the flat bar referred to, the wedges readjusted to bring up to level, and when grouted in again the machine is as true as when originally set down.

Where there is a big demand for these gears, experience has taught that a separate small machine for dealing with pinions is more economical than cutting the same on the big machines referred to. This machine is illustrated on page 183, and the design of the gearing is so arranged that the angle produced in the wheel on the large machine is identically reproduced in the pinion on the small machine.

Dynamic Balancing.

Another factor in the even running of these gears is either static or dynamic balancing. The author has known gears that on test were giving very indifferent results completely transformed into excellent gears by correcting them for balance.

The ordinary static method of balancing from experience was found insufficiently sensitive. The author has always felt that the proper test for this purpose is the running balance, such as is used in connection with loco wheels and axles. The running test shows the effect of couples, which is not disclosed in the statical balancing. In this connection it is interesting to note that the Akimoff rotary balancing machine has been put on the market for this purpose.

The question is often asked if one or more cuts are recommended, in removing the material from the tooth space—the answer is, one cut where possible, or if a finisher is desired the final cut should be in the region of 0·010 in. In the author's opinion it is at the first stage that the bulk of the small variations are introduced into the work, and once present cannot be entirely removed by a finishing cut. They seem to reproduce themselves. This point does not seem generally known. In removing the material in two half-depth cuts, the first cut is trying to insert a number of teeth in the blank not in accordance with the dividing mechanism. This strain plays upon the want of homogeneity in the blank. Soft and hard places allow the hob in some parts to cut more or less freely, so playing upon the accumulated wear or backlash of the dividing worm. Obviously the deeper the first cut the more the hob and dividing mechanism are in accordance and less likely to introduce extraneous errors. As a case in point, the author has known where a zero section of 20 teeth of the dividing wheel had in the corresponding length of the circumference of the work above it an extraneous added error of ·008.

The application of turbine reduction gear is now generally recognised as an established success. Some controversy has arisen quite recently as to whether or not hobbing is the best method of producing this type of gearing, and considering that 90 per cent. of the reduction gears in use have been cut on these machines, is surely satisfactory evidence of the efficiency of the hobbing process.

The machine described has been installed in practically all the principal shipbuilding works in the world: many of these machines, during the stress of the war period, were running continuously night and day, and the consistent success in the absence of trouble from the dividing standpoint should be realised.

This even cutting is characteristic of the hobbing process. The inherent steadying and helpful property of the hob should be appreciated; whatever errors appear in the work, and they are generally very slight, are distributed over sections. Absence of the thick tooth, which is the worst form of inaccuracy, is, from the very nature of the hob, eliminated, and at the same time is the chief danger of the planing process, especially in dealing with work of a diameter in excess of the dividing wheel.

The author holds no brief for hobbing, but is as equally interested in the planing process. He holds with planing in the case of large pitches, especially in steel blanks, because the routing properties of the hob are very limited. The question is often asked if multiple thread hobs are recommended, and if the idea is quick production the answer is in the affirmative, but if extreme accuracy is the main issue, then the answer is in the negative. It should be borne in mind that the multiple pitch hob is not all gain, because along with it there is often a reduction in the down-traverse, so that in the end, from the standpoint of extreme accuracy, it is questionable if the gain is worth the risk.

No doubt many readers have followed some of the recent papers on turbine reduction gearing, and referring to the very interesting paper by Mr. Walker on that subject, it will be noted that in some case difficulties have cropped up, especially in regard to double-reduction gears. The principal remedy suggested, when all is boiled down, is greater accuracy in the cutting of the gears, and an admonitory finger is pointed at the machine tool.

It may be as well at this stage to obtain a definite demonstration of what present-day accuracy is, and the fineness of the errors in these hobbed gears, because, to my mind, misleading statements are being permitted to pass on the subject of gear hobbing, which are in direct opposition to facts. To illustrate this, the author has had a gear commercially produced straight from the machine. It was parted circumferentially at the middle so as to enable one portion to be turned with its teeth diametrically opposite—a crucial test, as it brings the plus and minus sections in opposition—the actual error, of course, being half the discrepancy shown.

It was found that there was practically no pitch error; the even accumulation in a length of circumference of 6 ft. was only five two-thousandths, that is, ·0004 per tooth. This result should be appreciated, because it is very questionable if there is a lathe guide screw in existence with less variation. Further, its accuracy is immeasurably superior to the Admiralty standard of one-hundredth of an inch in 6 ft.

The condition of the gears, when testing in the workshop for bedding, is not the same as when running under load; that is, gears cut carefully and generated truly will, in the shop, show bedding that may be considered highly satisfactory and practically theoretically correct, yet when put into service give evidences of inaccuracies which are not in accordance with the rolling curve theory. Does not this give evidence of other factors in the question? Does it not point to distortion in the gears or in the gear casing, setting up an abnormal and altered condition of affairs? Look at the compromise. The points of the teeth must be rounded off to ease digging in that occurs from some reason not yet explained, and the teeth of the pinions barrelled, to clear for what must be cross twist in the length of the teeth, otherwise does it seem necessary to take all these precautions for the errors in such gears?

It is a well-known fact that weight in these gears is to be avoided as much as possible, but if weight saving is carried too far extreme accuracy of contact under full load under such circumstances will probably be sacrificed. Many of the gears appear to be wanting in rigidity, and when powers that run up to as much as 140,000 b.h.p. pass through them, distortion is distinctly probable. In further support of this view, it is known that gears which have proved unsatisfactory in service have been replaced by a similar set but very much heavier that have then given every satisfaction in running.

The author desires to acknowledge assistance from many firms engaged in this undertaking, in particular, Parsons Marine Steam Turbine Company Limited; John Brown & Co. Limited, Clydebank; Wm. Beardmore & Co. Limited; Richardsons Westgarth & Co. Limited; and R. & W. Hawthorn, Leslie & Co. Limited.

NODAL ARRANGEMENTS OF GEARED DRIVES.*

By Dr. J. H. SMITH.

An inspection of the teeth of gear wheels which have seen service in a faulty arrangement will convince the most optimistic that hammering has been taking place. Pitting is found at the pitch line, rapid wear occurs and grooving of the faces of the teeth appears; flakes and particles of metal are found in the oil drains; the edges of the teeth are sometimes frayed and occasionally the teeth are torn off at their roots and show typical fatigue fractures, thus revealing the presence of fluctuating stresses of range from 30 to 40 tons per sq. in.; irregularities of pitch sometimes appear. All these items suggest that the teeth have been hammered in a violent and periodic manner. The matter is serious in the case of some double-geared ships; there are apparently quite a number running below their economical and designed speed owing either to this trouble or fear of it.

Various methods have been suggested for the reduction or elimination of tooth pressure fluctuations and hammering actions, but in all such changes the object in view has evidently been to obtain the effects of more accurate cutting and lower surface pressure. The modern tendency as regards tooth pressure appears to be to return to 500 lb. or 600 lb. per in. width of wheel, a value used by Boulton & Watt for rough, cast-iron wheels. It would appear, then, that we are not advancing very rapidly in this branch of engineering. As regards the general arrangement of a geared drive, it has been suggested that flywheels and elastic couplings should be added. Elastic shafts of various forms and elastic wheel rims have also been suggested, introduced in some cases with the object of securing a more uniform distribution of load over the width of the wheel, in others with the object of allowing for irregularities in the teeth.

Investigation.

With the object of attempting to obtain a solution of the problem of geared propulsion the writer was invited by Mr. Chas. E. Allan, director of Workman, Clark & Co., Belfast, to carry out an investigation on both experimental and mathematical lines. On taking up this work the writer was brought into touch with an interesting example of a roaring ship. The peculiar behaviour of this ship he found could not be explained in any manner by a simple theory, and he was gradually led into a full investigation of the whole question on the broadest possible lines. The main features of the mathematical side of the investigation in their simplest form are recorded in this paper, the results of this investigation leading to what appears to the author to be the only possible solution of the problem.

In order to simplify a proposed elastic shaft geared drive, with the object of securing an arrangement which shall have the least number of possible critical speeds, and therefore the least chance of coincidence of any of these with any impressed periodic actions arising either from the action of unknown internal irregularity or known and unknown external periodic disturbances, a certain amount of ingenuity is required. No common line of procedure can be chosen which will be suitable for the most general arrangement.

When designing a drive we may have to study the peculiarities of the known disturbing elements, and in some cases it may be necessary to split these elements into their component parts. In all such cases the component parts will consist of a fundamental and a series of harmonics having periodicities simple multiples of the periodicities of the main feature of the disturbance. Such considerations will lead to the formation of a family of periodicities. An arrangement of the drive will then have to be made of such a nature that the possible critical speeds are so placed that synchronism does not occur between any one of them and any member of the family of the impressed periodicities. General considerations on a question such as this are, of course, always difficult to deal with, but after carefully considering the possible variations of the numerous elements with which we are concerned in elastic shaft geared drives, the writer is led to the opinion that the required reductions are best secured by :—

(1) Simplifying the system.
(2) Tuning the system.
(3) Making the elasticities and masses of certain shafts dynamically similar.
(4) Adjusting the phases of the disturbances.
(5) Attempting the elimination of high periodicity disturbance by lowering the pitch of the possible free vibrations of the system.
(6) Arranging the periodicities of the disturbance in a definite and simple family.
(7) Reducing the moments of inertia of the wheels of the attendant train to the least possible value.

There may be other items worth considering, but so far the writer has not discovered them.

Simplification of Systems.

The difference in behaviour of single reduction and double-reduction systems would appear to be partly explained as arising from the simple nature of the former. In a single-reduction arrangement there are only one-half the number of tooth connections, and hence, roughly speaking, only one-half the number of possible critical speeds and smaller critical speed ranges than in the corresponding double-reduction arrangement. With the present haphazard method of designing, then, the single-reduction arrangement has a far better chance of success than the corresponding double-reduction type. The suggested use of a flywheel on the propeller shaft is without doubt a mistake; it would increase the degrees of freedom of the system and hence the number of possible critical speeds. Any change in the moments of inertia of the propeller or of the shaft dimensions would not increase the number of possible critical speeds, and is therefore not objectionable. It may be observed also that we must cut out all elastic shafts in the gear box; that is, we must bind the driver and driving wheels mounted on any shaft as rigidly together as possible.

In a tuned system, then, we may say that very great reductions have been made in the possible number of critical speeds. The following table will give some idea of the changes which can be made by tuning alone in a complex system, consisting of n shaft and m toothed connections.

Critical Speed of Tuned and Untuned System.

Critical Conditions.	Number possible in Untuned System.	Number possible in Tuned System.
Acceleration of gear wheels	n	1
Free vibrations	n	2
One couple acting on one shaft	$2nm + n$	$4m + 2$
One couple acting on each shaft	$2n^2m + n$	$4nm + 2$

The critical speed ranges are reduced from n to 2 in all cases.

Simplification secured by the adoption of dynamical similarity.—It is often possible to make a group of shafts, together with their attached masses and transmitted torques, dynamically

* Abstract of paper read at the Spring Meetings of the Sixty-third Session of the Institution of Naval Architects, April 6.

similar, and in such cases the behaviour of all the shafts in the group becomes identical and can be treated as one individual shaft. In this way the number of tooth connections are reduced from the number appearing in the group of shafts to the number appearing in one shaft, and hence the critical ranges will be the same for all members of the group. The simplest conditions to be satisfied in such a reduction are, first, that the shafts of the group are tuned to the same free periodicity; second, that the masses mounted on the shafts are identical; and third, that the torques transmitted by the shafts are the same. It may here be noted that dynamically similar shafts do not help in simplification unless the system is tuned.

Adjustment of Phase of Disturbances.

In certain cases the phase of the disturbing periodic couples will be known with a fair degree of accuracy, and hence by an adjustment of various shafts it will be possible to arrange that these couples cancel each other when taken in pairs. In such arrangements the shafts considered will have to be tuned to the same periodicity and assembled in an appropriate manner. As an example of this, we might mention that the simplest nodal arrangement which could be devised, if the elimination of the fluctuation torque arising from propeller blade disturbance is the important consideration, would consist of twin propeller shafts connected to one gear box and suitably assembled.

Lowering of the pitch of possible free periods.—The author suspects that in many cases angular oscillations have been occurring in turbine rotors and have been so pronounced as to give rise to appreciable fluctuating couples. If such periodic torques are possible it would appear that they can only be high periodicity effects, and can only be avoided by tuning down the possible free vibrations of the system to the lowest pitch.

Periodicity of Disturbing Torques.

In seeking simplification one is naturally tempted to consider not only the method of reducing the number of critical speeds but all other aspects of the question. The periodic disturbing couples, large or small, do not appear to offer anything promising in this direction at first, but a little consideration will show that a simplification is possible here. At the present time there appears to be no attempt made in this direction. How the speed ratios of the various elements of a geared drive are chosen one would have difficulty in finding out. As a matter of fact such a question, in the writer's opinion, is treated in the same way as many others in this branch of engineering. If we consider the simple case of a three-shaft drive, and for simplicity assume that the chief disturbance arises from propeller blade action, it will be seen that the possible periodicities are b N, 2 b N, 3 b N, &c., where b is the number of blades in the propeller and N is the revolutions per minute. These periodicities will be effective, and it is therefore absurd to add further periodicities to this long series. In order, then, to reduce the disturbances to the smallest and simplest possible family, the speeds of rotation of all other elements of the system should be arranged so that they are members of this family and not strangers. That is, the speeds of the primaries and the turbines should belong to this family.

Moments of Inertia of the Wheels.

It can be shown that the smaller the moments of inertia of the attendant wheels the more nearly do the various critical speeds merge into one value, and hence the smaller speed range over which these criticals are spread. We may look upon the matter in perhaps a simpler way: for example, in an ordinary three-shaft arrangement the most dangerous elements would appear to be the primaries; when working at or near a critical speed, these wheels are instantaneously free and uncontrolled by elastic connections, and hence may take up independent rebounding hammer motions. If such a thing is possible the only way we can reduce the effect is by reducing the "weight of the hammer," *i.e.*, the moment of inertia of the primary wheel. In the single-reduction arrangement the hammer does not exist.

General conclusions on simplification.—We are led, as a result of our investigation, to the conclusion that the tuning or nodalising of any geared drive is the most direct and important dynamical means of attacking the problem when our object is the reduction of the number and magnitude of the possible critical speed ranges.

Three-Shaft Arrangements.

In order to illustrate the use of the general equations and conclusions deduced, the author deals in a broad way with two simple problems, in which the arrangement of gears and elastic shafts consists of two prime mover shafts geared to one propeller shaft, namely, the common form of arrangement used in ship propulsion. If it was desired to carry our simplification in a haphazard design to the utmost limit, the arrangement would be made to consist of either a single-reduction train, or if not possible, then double-reduction train with only one prime mover, as in this way the critical speed ranges would be cut down to a minimum. A double-reduction arrangement with one prime mover will possess almost all the advantages of a single-reduction arrangement with two. In any case we shall reduce our system to a one mass per shaft system, and where double reduction is employed shall employ rigid shaft connections between the primary wheels and pinions, and make the moment of inertia of the primaries of the least possible amount.

Critical Speeds.

It is shown that for the simplest possible three-shaft arrangement there are two critical speed ranges, or ten critical speeds when double-reduction gearing is employed, and six critical speeds when single-reduction gearing is used. The problem, then, is reduced to the adjustment of the critical speed ranges, or critical speeds, so that they fall in positions amongst the family of impressed speeds in such a manner that neither coincidence nor approximate coincidence is met with over that part of the speed range which is considered important. This is, in general, a fairly simple thing to do when a design is being prepared *ab initio*, but would appear to require some little patience and ingenuity when one is concerned with the conversion of haphazard arrangements.

Clearly defined critical speeds are apparently seldom met with in haphazard arrangements, and hence the writer is of opinion that there is no clearly defined oscillating system in the majority of cases, but a hopeless jumble of vibrations and chatter to which mathematics cannot be applied. It may be maintained that the high periodicity criticals are outside the working range of the arrangement. The writer cannot see how this can possibly be as the number of impressed speeds covers such a wide range, and when the harmonics of the propeller's disturbance are considered, such suggestions seem altogether out of the question. The writer has spent a great amount of time in analysing oscillating systems of the three-shaft kind, and has never yet found one case of haphazard arrangement where all the criticals were not below the speed of revolution of the highest speed turbine shaft.

It appears to the writer that the most dangerous type of critical speed is that of high periodicity. Such criticals are dangerous because we have no clear evidence of their presence except in the rattle and roar, which when once started gradually increases in volume as the speed increases. It was the peculiar behaviour of a true roarer which led the writer to suspect that there were other disturbances to be taken into consideration besides those arising from propeller blade action.

DOUBLE-REDUCTION GEARS IN THE SS. "MELMORE HEAD."*

By J. W. WILKIE.

In the controversy which has centred round the problem of double-reduction gears during the past few years it has been exceedingly difficult to collect reliable information regarding the troubles which have been experienced with this type of drive. Excessive noise in the engine room, with hammering of the gears, would appear to have been all too common in gear-driven ships. When this is the case heavy flaking of the gears in the neighbourhood of the pitch line occurs, with grooving and deformation of the teeth and occasional fractures of the teeth, which clearly suggest fatigue of the material. While this must have been the experience of many there are those who assert that there is nothing wrong with double-reduction gearing. If this is the case one naturally wonders why it should be necessary to run many of our geared ships at reduced powers and to design the gears for new installations at half of the original tooth pressures, thereby greatly increasing the weight and cost of gears. With so much conflicting evidence there is good ground for the appeals which have been made for giving all the facts available regarding the performance of double-reduction gears at sea. By the courtesy of the directors of the Ulster Steamship Company and the directors of Workman, Clark & Co., of Belfast, the author is enabled to give a detailed account of the troubles experienced with double-reduction gearing in the *Melmore Head*, together with a description of the methods recently adopted to overcome these troubles.

Description of SS. "Melmore Head."

The *Melmore Head* is a single-screw steamer of 2,500 s.h.p., driven by double-reduction geared turbines. This ship was built and engined by Workman, Clark & Co., and delivered to her owners in September, 1918. Fig. 1 (page 192) shows the arrangement of the turbines and gear, while Fig. 1A shows the relative positions of the pinions and wheels. The revolutions of the various elements are :—

	Per Min.
High pressure and intermediate pressure turbines and pinions	3,600
Low-pressure turbine and pinions	2,400
Second reduction pinions	560
Main shaft	70

The second reduction gears are designed for a working pressure of 1,000 lb. per inch width of tooth, and at 70 r.p.m. the constant $P\sqrt{d}$ is 274. The machinery is placed amidships, and the length of the main propelling shaft from the gear to the propeller is 144 ft. In her regular service across the North Atlantic the *Melmore Head* makes the outward voyage in ballast and the homeward voyage loaded. As several sets of gearing have been fitted to the original gear case at different times these will be designated by numbers in order that the sequence of events may be clearly followed. Particulars of the various gear arrangements are given in Table I.

Gear No. 1.

In erecting this gear in the shop every precaution was taken to ensure accurate alignment, and the same care was taken to ensure this alignment being maintained when the gearing was put in position in the ship. The running of this gear on the trial trip was very unsatisfactory. The noise in the engine room was deafening, while at the gear case it was evident that the gears were hammering each other in a most alarming fashion. This hammering of the gearing was not confined to any one particular speed, but could be distinctly traced at all speeds up to the maximum. It was confidently expected that after a short time at sea the general conditions in the engine room would improve, that the teeth would become properly bedded to each other, and that the hammering would cease. Such a state of affairs, however, was never realised, and each succeeding report from the chief engineer merely indicated that matters were getting worse. This was confirmed by personal observations on the part of the author. It has been his practice, until quite recently, to either meet the ship on her arrival in Belfast Lough or to accompany her to her coaling ports on the Clyde or Bristol Channel, in order to trace the various developments in the problem.

A careful examination of the gearing at the end of the first voyage showed a considerable amount of flaking of the teeth and grooving at the pitch line. By the end of the second voyage this had increased considerably, and in addition, a sharp protruding edge was being formed on the teeth of the

Table I.

	Gear No. 1.		Gear No. 2.		Gear No. 3.		Gear No. 4.		Gear No. 5.		Gear No. 6.	
	P.C.D.†	Circular Pitch.	P.C.D.	Circular Pitch.	P.C.D.	Circular Pitch.	P.C.D.	Circular Pitch.	P.C.D.	Circular Pitch.	P.C.D.	Circular Pitch.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
H.P. pinion	7·143	0·8976	7·06	0·6	Gear No. 2 retained		Gear No. 2 retained		7·06	0·6	7·062	0·6778
H.P. primary wheel	45·714	0·8976	45·798	0·6	Gear No. 2 retained		Gear No. 2 retained		Gear No. 2 retained		45·795	0·6778
L.P. pinion	10	0·8976	9·923	0·6	Gear No. 2 retained		9·925	0·6778	9·925	0·6778	Gear No. 5 retained	
L.P. primary wheel	42·857	0·8976	42·935	0·6	Gear No. 2 retained		42·936	0·6778	Gear No. 4 retained		Gear No. 4 retained	
Second reduction pinions	13·333	2·094	13·507	0·8	13·495	1·1458	Gear No. 3 retained		Gear No. 3 retained		Gear No. 3 retained	
Main wheel	106·667	2·094	106·493	0·8	106·504	1·1458	Gear No. 3 retained		Gear No. 3 retained		Gear No. 3 retained	

Note.—Figures are inserted where the parts have been renewed.
†P.C.D. = Pitch Circle Diameter.

* Paper read at the Spring Meetings of the Sixty-third Session of the Institution of Naval Architects, April 6.

second reduction gears. This was removed before the third voyage was started. During the second voyage also, considerable trouble had been experienced through choking of the oil filters by steel particles from the gearing, and, in addition, a slight fore-and-aft movement of the second reduction pinions was detected. The outward portion of the third voyage was safely completed, although the choking of the oil filters and the movement of the second reduction pinions were increasing. When 400 miles of the homeward voyage had been covered, however, the movement of the pinions had become so violent and the consequent pounding of the gears and vibration of the gear-case so severe that speed had to be reduced, and Norfolk, Va., U.S.A., was made with very great difficulty. In this port temporary thrust pads had to be fitted to the ends of the second reduction pinions to hold them in position. By this means it was possible to run the machinery at a speed sufficient to maintain steerage way on the ship while she was being towed home by another of the company's vessels. Between September, 1918, and April, 1919, when this gear collapsed, approximately 25,000 miles had been covered at full power. Particulars of the speeds and revolutions are given in Table II.

Two reasons were put forward for the failure of this gear: these were, inaccuracies in cutting and faulty alignment. As regards alignment great care had been taken with this in the course of construction, and when the gear wheels were removed it was again checked by mandrels in the gear case bearings, and found to be correct. This being the case the whole cause of the trouble was attributed to inaccurate cutting of the gears. It was decided, therefore, that new gears of finer pitch (particularly in the case of the second reduction gears) should be put in hand, and that these should be cut by a different firm of gear cutters.

Gear No. 2.

The gear wheel and pinions in this case were mounted in the gear case on board the ship. The alignment of all the parts was carefully examined, and all concerned (including the gear cutters) were satisfied as to the accuracy of the work. Had any doubt existed this was removed by an examination of the tooth markings after the trials had been run. The performance of this set of gearing on trial showed very little improvement on the performance of the first set. The noise in the engine room was still excessive, and the hammering of the gears was much in evidence. Nevertheless, the ship went on her fourth voyage at designed speed. While this gear lasted the rattle and roar in the engine room remained undiminished. The gears were examined at the end of each voyage, and although the wear on the teeth did not appear to develop as rapidly as in the first gears, signs of the old troubles with flaking and grooving were not wanting. At the end of the fourth voyage the pressure of the oil supply to the gears was increased by raising the level of the gravity supply pipes to the top of the engine-room casing. No appreciable change in the noise resulted from this alteration, however, and the fifth voyage was completed under the similar uncomfortable conditions of previous voyages. The sixth voyage of the ship, and the third with this set of gearing, saw the collapse of Gear No. 2. On the passage up the St. Lawrence River the second reduction gears stripped half-way across the face of each pinion and wheel shroud. Between August and November, 1919, this gear had completed approximately 14,000 miles at full speed. Temporary second reduction gears were despatched to Canada, and after these were fitted up the ship returned to Belfast at about half-power.

An examination of the fractured teeth of this second set of gears showed that all the teeth had been broken off sharp at the roots without any sign of elastic deformation. From this it was concluded that the material had given way under fatigue stress, and this was subsequently confirmed by tests carried out at the steel works. It appeared, therefore, from an examination of all the facts available, that stresses of a nature or magnitude not anticipated in the original designs were being transmitted through the gears, and that lower tooth pressures would have to be employed if the gearing was to be made to work satisfactorily. Accordingly it was decided to re-design the gear case and to limit the maximum tooth pressure to 500 lb. per inch width. This gear was actually completed, but, as subsequent developments proved, it was never necessary to have it installed in the ship.

Gear No. 3.

As the demand for tonnage at this time was very great a third set of second reduction gearing was installed to work in conjunction with the primary gears retained from Gear No. 2. With this arrangement the ship was to be kept in commission at reduced power until the new gear case was ready. Three voyages (Nos. 7, 8 and 9, Table II) were completed with this arrangement before any modifications were made. The average speed over these three voyages was 7·5 knots at 48·5 revolutions, giving a value of 132 for the constant $P/\sqrt{d}$. The running conditions with this gear, even at reduced power, were not too satisfactory. While the engine-room conditions were certainly tolerable, there was clear evidence of the former hammering action of the gearing taking place. The intensity of this action was, of course, greatly diminished owing to the reduced speeds of rotation of the wheels, at the same time a reduction of the constant from 274 to 132 had not produced that smoothness of running and absence of noise so essential for the preservation of the gear for any considerable time. In the author's opinion the method of attacking the gearing problem by simply reducing tooth pressures was not satisfactory. It seemed to be more or less a shot in the dark supported by no sound argument, and was likely to prove a tedious and costly method of experiment.

From a careful study of the observations made from time to time on the *Melmore Head* the writer came to the conclusion that the gear transmission system as a whole was dynamically unsound, and that if satisfactory running of the gears was to be obtained some consideration would have to be given to the inertia effects of the various rotating masses, and particularly to the effect of torsional vibrations of the propelling shaft arising from propeller action in a variable wake. Shortly after the third gearing arrangement was installed Professor Smith was called in to investigate the problem on behalf of the builders, and the writer became associated with him in carrying out the subsequent changes which were made from time to time. The mathematics of the problem has already been discussed in Dr. Smith's paper on "Nodal Arrangements of Geared Drives" (*see* page 188). The writer will, therefore, confine his remarks to a description of the various changes made on the *Melmore Head*.

Table II.—*Extracts from Log of* ss. *Melmore Head*.

Voyage Number.	Speed in Knots.	R.P.M.	Gear.
(1) Outwards	10·8	69·2	No. 1
Homewards	10·8	70·0	No. 1
(2) Outwards	10·87	70·4	No. 1
Homewards	11·1	69·0	No. 1
(3) Outwards	11·5	71·3	No. 1
(4) Outwards	12·2	71·0	No. 2
Homewards	11·0	67·1	No. 2
(5) Outwards	11·6	72·0	No. 2
Homewards	9·9	67·1	No. 2
(6) Outwards	11·7	71·6	No. 2
(7) Outwards	7·5	49·4	No. 3
Homewards	7·8	50·5	No. 3
(8) Outwards	7·5	47·1	No. 3
Homewards	7·7	48·3	No. 3
(9) Outwards	7·8	48·3	No. 3
Homewards	6·3	47·4	No. 3
(10) Outwards	7·4	49·6	No. 4
Homewards	8·0	52·6	No. 4
(11) Outwards	10·2	65·3	No. 5
Homewards	8·0	52·7	No. 5
(12) Outwards	8·0	54·9	No. 6
Homewards	9·4	59·6	No. 6
(13) Outwards	10·1	62·3	No. 6
Homewards	9·9	63·2	No. 6
(14) Outwards	11·3	68·3	No. 6
Homewards	9·9	64·0	No. 6
(15) Outwards	11·5	68·0	No. 6
Homewards	9·5	62·5	No. 6

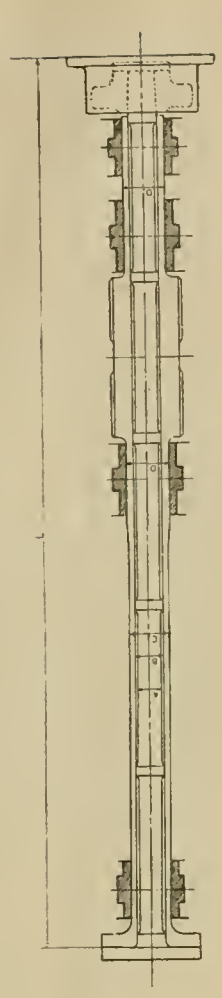


Fig. 2.

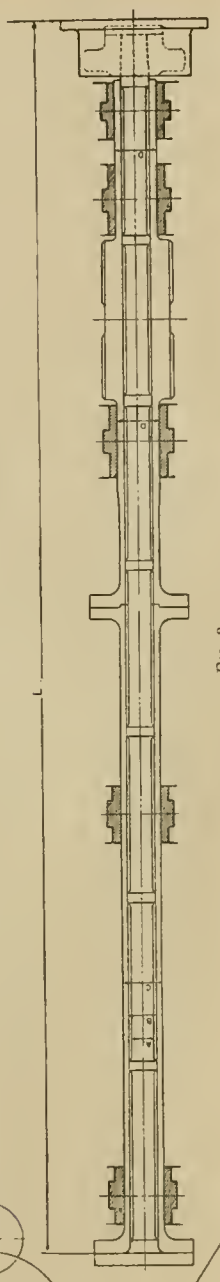


Fig. 3.

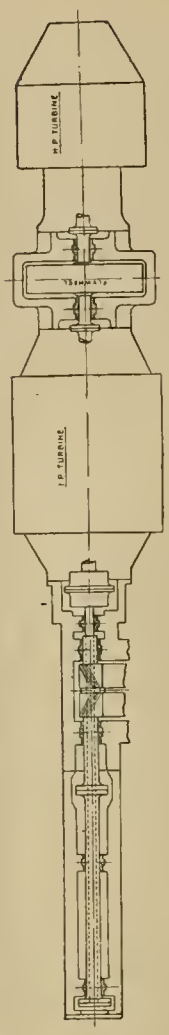


Fig. 4.

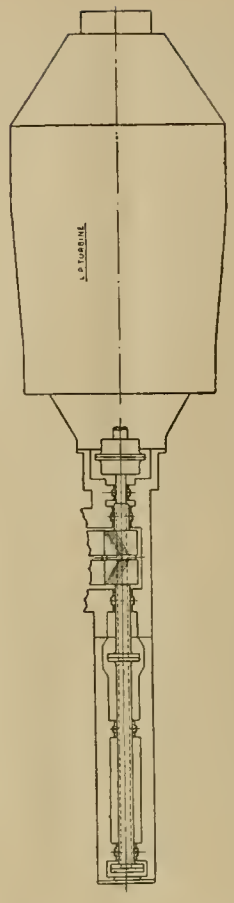


Fig. 5.

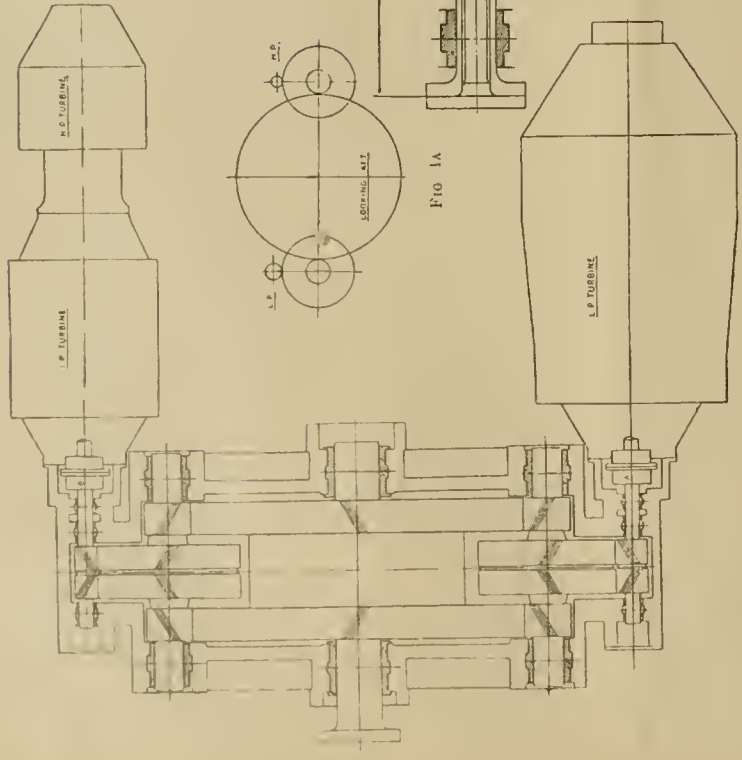


Fig. 1.

Fig. 1A.

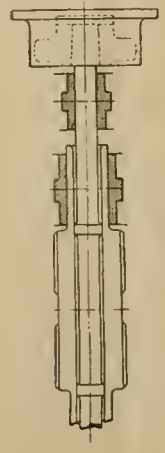


Fig. 6.

SS. "Melmore Head."—Arrangement of Turbines and Double-Reduction Gears showing Nodal Drive.

It had been observed at various times that the hammering effects in the gear appeared to be most severe at the low-pressure side. The reason for this was believed to be that because of its mass and the rigidity of its connection to the gears the low-pressure turbine was unable to keep step with the fluctuations in speed of the main wheel which resulted from torsional oscillations of the main shaft. Parting of the teeth would, therefore, occur with hammering when contact was resumed. It was decided, therefore, as a first experiment to adjust the shaft connecting the low-pressure turbine to its primary pinion in such a way as to make the periodicity of the free torsional oscillations of the low-pressure turbine about the main gear wheel equal to the periodicity of the free torsional oscillations of the propeller about the main gear wheel.

Gear No. 4.

To carry out the idea of tuning the low-pressure turbine and its driving shaft to the same periodicity as the propeller and propeller shaft, the pinion shaft A in Fig. 1 was removed and replaced by a hollow-bored pinion shaft with an internal flexible driving shaft as illustrated in Fig. 2. The principal dimensions of this arrangement were A = $2\frac{9}{16}$ in., B = $2\frac{11}{16}$ in., C = $4\frac{1}{16}$ in., D = $4\frac{1}{2}$ in., L = 7 ft. 10 in. The stress on the internal shaft was 9,900 lb. per sq. in. The collars on the internal shaft were made a sliding fit in the bore of the pinion shaft and were introduced to prevent any possible whipping of the internal shaft. As the primary wheel on this side of the gearing was badly grooved it was decided to renew this wheel in addition to fitting the new pinion. Otherwise it is to be particularly noted that no other change was made on the gearing, and that the second reduction gears remained exactly as when originally fitted in arrangement No. 3 at the end of voyage No. 6.

This arrangement was thoroughly tested on trials run at full power in Belfast Lough. The effect produced in the running of the gear by the introduction of this flexible drive was most encouraging. The hammering of the gears had entirely disappeared at the low-pressure side, and instead a pure rolling of the teeth was produced. The gear case, which had previously vibrated considerably, was not perfectly steady, and generally the conditions in the engine room were comfortable. As was anticipated, of course, hammering was still evident at the high-pressure side of the gears, due to the fact that no adjustments had been made on that side. Although the trials of this arrangement had proved so satisfactory it was decided to make the next voyage at a speed not exceeding 50 r.p.m. The reason for this decision was that the arrangement was purely experimental and of a temporary nature, and the stresses adopted for the flexible driving shaft were unusually high. This voyage—No. 10 in Table II—was successfully completed, and at its conclusion a careful examination of the gears showed no grooving or pitting of the teeth. It may be argued, of course, that one voyage of approximately 7,000 miles is too short a period in which to draw any conclusions as to the condition of the teeth. With the first and second gears, however, there was no doubt as to what was happening to the gear teeth long before that distance had been completed.

Gear No. 5.

As a result of the experience gained in the first experiment it was now decided to tune both turbines and their driving shaft to the same periodicity as the propeller shaft. This time the stresses in the driving shaft were reduced from 9,900 lb. to 7,500 lb. in order to provide a sufficient margin of safety for continuous working at full power. Stresses lower than 7,500 lb. were considered impossible in this ship, as the driving shafts would have become too long to be satisfactorily supported. Pinion shafts A and B in Fig. 1 were replaced by hollow-bored pinion shafts with extension sleeves and internal shafts as shown in Fig. 3. The principal dimensions of these shafts were :—

	High-pressure Side.	Low-pressure Side.
A	$2\frac{1}{2}$ in.	$2\frac{1}{4}$ in.
B	3 in.	$3\frac{3}{8}$ in.
C	$4\frac{1}{4}$ in.	$4\frac{1}{8}$ in.
D	$4\frac{1}{2}$ in.	$4\frac{1}{8}$ in.
L	10 ft. $10\frac{3}{16}$ in.	10 ft. $10\frac{3}{16}$ in.

As the length of the high-pressure driving shaft could not be made sufficiently long to completely tune this side of the system it became necessary to increase the inertia effect of the high-pressure and intermediate-pressure turbines in order to tune them to the same periodicity as the propeller, and to obtain an approximate balance between the two sides of the driving system. This increase of inertia was accomplished by introducing a flywheel between the high-pressure and intermediate-pressure turbines. The position of the flywheel between the turbines was chosen with the idea of binding the three elements in such a way as to form approximately one rigid mass, and thus avoid the possibility of independent vibrations being set up between those three units. This flywheel, with its shafts, was a solid forging of 34-38 tons steel, the diameter of the wheel being 3 ft. $\frac{1}{2}$ in., the breadth $9\frac{3}{16}$ in., and the weight 2,270 lb. The flywheel is shown in Fig. 4. This arrangement of flexible shafts and flywheel was fitted up at the conclusion of voyage No. 10. It is again to be particularly noted that no adjustments were made on the second reduction gears, these remaining exactly as when originally fitted at the end of voyage No. 6.

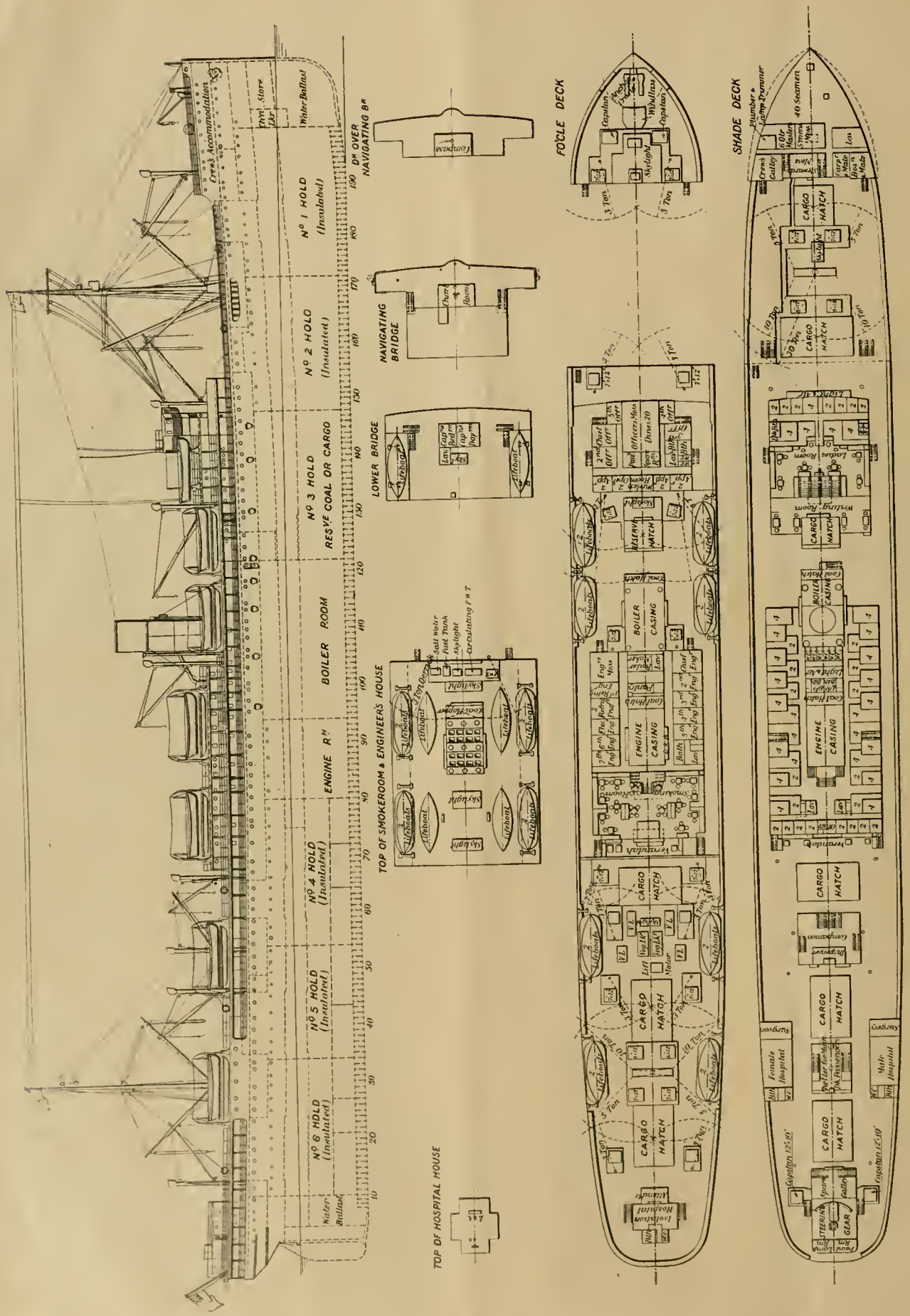
Trials at full power were run with this arrangement, and the results were considered to be very satisfactory. The absence of hammering in the low-pressure primary gear and at both sides of the secondary gears was particularly noticeable. One defect remained, however, which subsequently proved to be more important than was anticipated. Doubtless many members were present when these trials were run in Belfast Lough, and they may have noticed a slight vibration at the high-pressure primary gear.

When the new pinion and flexible shaft were fitted to the high-pressure side no change was made in the primary wheel. This wheel remained from Gear No. 2, and as it was only slightly grooved it was considered that it would run quietly with the new pinion and the flexible drive. On the trials, however, this condition was not quite realised, and a slight vibration developed at the high-pressure primary gear. With this one apparent defect remaining the ship set out on her eleventh voyage, the outward portion of which was completed at an average of 65·3 revolutions. The vibration at the high-pressure primary gear had increased somewhat by the end of this outward voyage, and as it continued to increase during the homeward passage speed was reduced and the voyage completed at an average of 52·7 revolutions.

Gear No. 6.

An examination of the high-pressure pinion at the end of this voyage showed that it had become grooved in exactly the same fashion as the primary wheel. It was evident, therefore, that to set a new and well-cut pinion to work in a worn wheel and expect quiet running conditions was a mistake, consequently both the high-pressure pinion and primary wheel had to be renewed. The flexible shafts were also withdrawn for examination at this time, and it was found that the collar at the flexible coupling end of each driving shaft showed considerable wear. This necessitated a modification of the design, and a bearing coupled to the forced lubrication system was fitted as shown in Fig. 6. This is the last modification that it has been found necessary to make on the gears of the *Melmore Head*. Fig. 4 shows the arrangement of the "nodal drive" as applied to the high-pressure driving element, and Fig. 5 shows the arrangement as applied to the low-pressure driving element.

(*Concluded on page* 200.)


Crew's Accommodation
Prov. Store
Water Ballast
No 1 HOLD (Insulated)
No 2 HOLD (Insulated)
No 3 HOLD RESVE COAL OR CARGO
BOILER ROOM
ENGINE RM
No 4 HOLD (Insulated)
No 5 HOLD (Insulated)
No 6 HOLD (Insulated)
Water Ballast
D.K OVER NAVIGATING B.K
NAVIGATING BRIDGE
LOWER BRIDGE
TOP OF SMOKEROOM & ENGINEER'S HOUSE
TOP OF HOSPITAL HOUSE
FO'CLE DECK
SHADE DECK
CARGO HATCH
BOILER CASING
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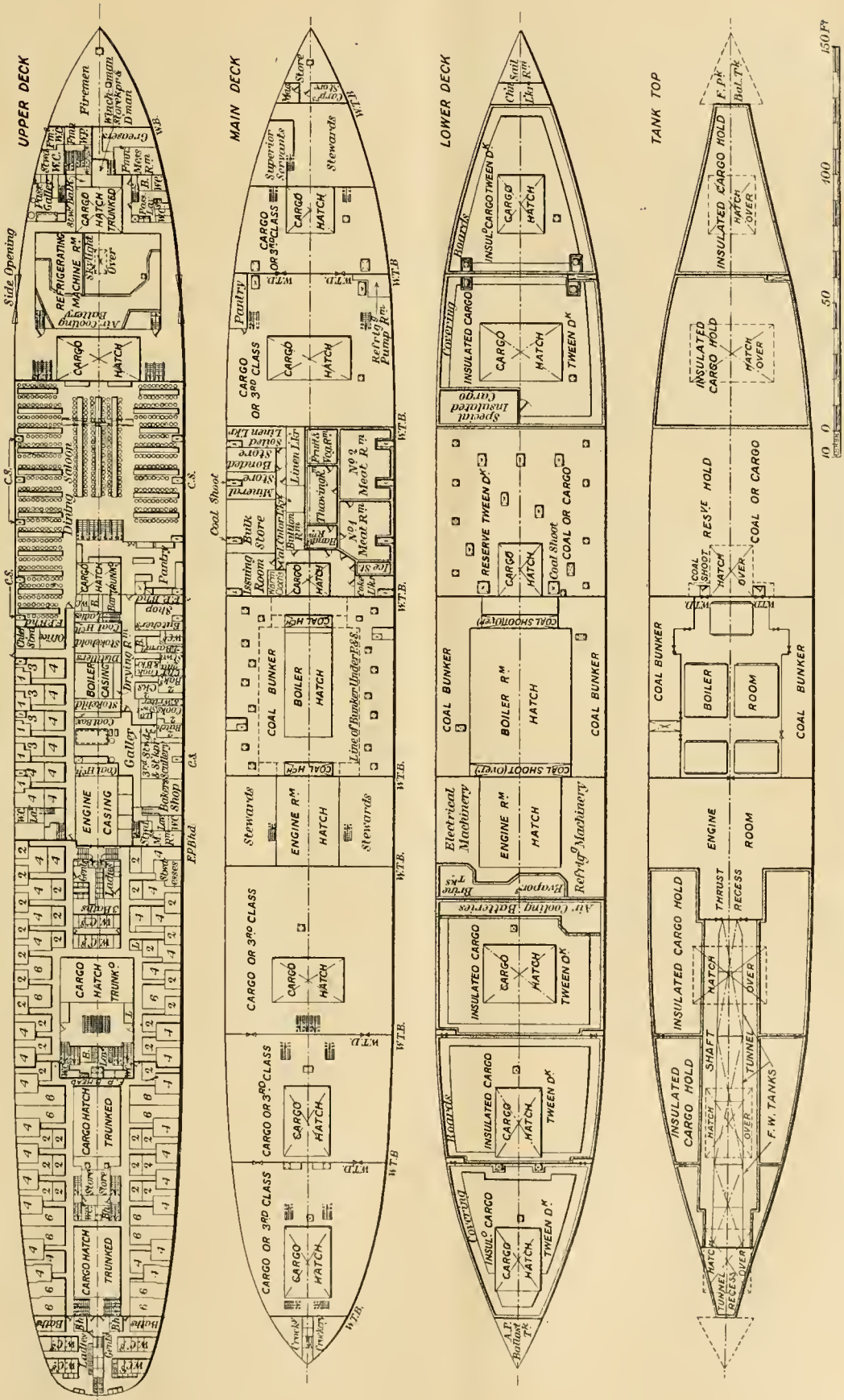
Hospital
Female Hospital
Male Hospital
Lifeboat



General Arrangement of the Twin-Screw Passenger Cargo Steamer "Ballarat," built by Harland & Wolff Ltd., Greenock, for the P. & O. Branch Line Service to Australia *via* the Cape. (*See page* 196.)

T.S.S. "BALLARAT."

Passenger-Cargo Steamer of 13,100 gross tons, built by Harland & Wolff Limited, Greenock, to the order of the Peninsular & Oriental Steam Navigation Company, London, for their Branch Line Service to Australia, via the Cape. Quadruple Expansion Engines by J. G. Kincaid & Co. Limited, Greenock.

The twin-screw steamer *Ballarat*, which was recently handed over to the owners, is the second of five vessels ordered by the Peninsular & Oriental Steam Navigation Company from Harland & Wolff Limited. The *Baradine*, which was built in Belfast, has completed her maiden voyage to Australia. Of the others, the *Balranald* was recently fitted out at Greenock, and the *Barrabool* at Belfast, while the *Bendigo* is now fitting out at Greenock. When completed, these vessels will increase the carrying capacity of the service to about 12,000 passengers, and 112,000 tons of merchandise and frozen cargo. They satisfy a popular demand for steamers carrying one class of passenger only at low fares—a demand which is likely to grow with the expected increase of emigration to the Colonies. The principal features of the vessel are as follows :—

Length, between perpendiculars	520 ft.
Breadth	64 ft.
Depth to upper deck	41 ft.
Draught, loaded	27 ft. 6 in.
Gross tonnage	13,100.
Length of shade deck promenade	370 ft.
Fresh water capacity	1,300 tons.
Bunker capacity (coal)	4,350 tons.
Total refrigerated space	345,000 cub. ft.
Total complement (passengers and crew)	1,520 persons.
Speed on service	14 knots.

Brief particulars of the propelling machinery and equipment are as under :—

Engines	Twin-screw quadruple expansion.
Cylinders	23½ in., 34½ in., 48½ in., and 70 in. diam. × 54 in. stroke.
I.H.P.	8,000.
Revolutions	95 per minute.
Propellers (each)	Three manganese bronze blades, cast-iron boss.
Diameter	17 ft. 6 in.
Pitch	17 ft. 6 in.
Surface	72 sq. ft.
Thrust blocks	Multi-collar horse-shoe type; effective surface (each) = 2,140 sq. in.
Main condensers	Weir's "Uniflux."
Cooling surface (each)	4,000 sq. ft.

Boilers :—

Three S.E. and two D.E. Scotch, arranged in one boiler room.
S.E. boilers, each 16 ft. 6 in. diam. × 11 ft. 8 in. long, with four furnaces 3 ft. 3 in. internal diam.
D.E. boilers, each 16 ft. 6 in. diam. × 20 ft. long, with eight furnaces 3 ft. 3 in. internal diam.
Distilling plant capacity, 6,000 gallons per day.

The vessel is classed 100 A.1 at Lloyd's, and has the Board of Trade passenger certificate and a safety certificate under the Convention for the Safety of Life at Sea. There are nine watertight bulkheads, of which eight are carried to the upper deck, the fore-peak bulkhead being carried to the shade deck. The double bottom extends all fore and aft, and to the sides of the ship. As a protection against fire, the passenger accommodation between the upper and shade decks is divided into four compartments by fireproof bulkheads. In all there are four complete decks, viz.: lower, main, upper and shade. There are also a top-gallant forecastle and a boat deck—the latter extending from the front of the bridge to the end of the counter.

Bunkers and Insulated Holds.

Situated in the boiler-room wings, the permanent bunkers extend to the underside of the upper deck, and, including the reserve bunkers, there is a total capacity of 4,350 tons of coal. This quantity is stated to be sufficient for the complete voyage to Australia. Of the six cargo holds into which the ship is divided, Nos. 1, 2, 4, 5 and 6 are insulated to the underside of the main deck with a total capacity of 336,000 cub. ft. frozen cargo. No. 3 hold is set aside for ordinary cargo or reserve coal. Nos. 1, 2, 4, 5 and 6 main 'tween deck spaces are available for carrying either emigrants or cargo, while No. 3 space is set apart for the purser's stores, consisting of 9,000 cub. ft. refrigerated space and 11,000 cub. ft. bulk. Two large refrigerating machines by the Haslam Foundry & Engineering Company are installed. These are adapted for the refrigeration of meat, butter, or fruit cargoes as circumstances may require. In the case of meat or butter, the holds are cooled by means of brine pipes fitted on the overhead, side and bulkhead insulation; but for fruit, air coolers are installed from which the air is circulated to the holds through trunks by means of powerful electric fans.

Accommodation.

Accommodation is provided for 491 passengers on the upper and shade decks, and 744 can be berthed in temporary rooms on the main deck. The passenger promenade on the shade deck extends for 370 ft. On this deck there are fitted a number of two-berth and four-berth cabins, every one of which has either a window or a port hole. On the port side of the upper deck, immediately abaft the dining saloon, is a small range of single-berth and three-berth cabins—an unusual arrangement for third-class passengers. These are let at a modest supplement, and are in great demand. The remainder of the cabins on this deck are for two, four and six persons, and although it is inevitable that there are a few inside cabins, these have been reduced to a minimum by the adoption of the "tandem" principle.

The dining saloon on the upper deck, forward of the machinery, seats 500 passengers. It is arranged with wide passages between the tables, and a companion-way 18 ft. wide in order that the large number of passengers may have easy access without crowding.

In the shade deckhouse over the dining saloon is situated the ladies' room, fitted with piano, bookcases, card tables, &c., and adjoining it are the writing room and main companion.

The smoking room is on the boat deck and is reached by a companion from the shade deck. Two verandahs, fitted with tables and seats, are provided, one on the shade deck and the other outside the smoking room on the boat deck.

The officers' cabins are at the fore end of the boat deck, and the engineers are housed on the same deck, alongside the engine casing. Separate mess rooms are provided for each group adjoining their cabins. Promenade space is reserved for them on the boat deck and lower bridge.

Hospitals for ordinary cases of illness are provided in houses on the shade deck aft, with surgery, dispensary, and lavatories adjoining. An isolation hospital is placed on the boat deck right aft, with attendant's room and lavatory attached. A doctor is always carried on these vessels.

The arrangements for preparing, cooking and serving food to the large number of people in this ship are most complete and up to date. There are three passenger galleys with bakery and scullieries, and a crew's galley, and four pantries, the main pantry being at the aft end of the dining saloon.

Some of the mechanical work in the galleys is done by electrical power, and electric lifts are provided to carry the food to the pantries.

The lay-out of the navigating bridge and its equipment has been particularly well conceived. The large wheelhouse, the wide spaces on the deck outside, a sun deck overhead, sheltered at the sides and in front of the wheelhouse by teak screens fitted with windows, give every facility for the work and comfort of the officers on duty. The outfit includes Lord Kelvin's patent compasses, telegraphs and telephones to the engine room, docking telegraphs and loud-speaking telephones to the forecastle and poop, telephone to the captain's room, MacNab's revolution indicators, &c. A new feature is the automatic steering tell-tale, by the Star-Port Company Limited, of London. It indicates by coloured electric lights the angle and direction of the rudder, so that the officer on watch can see at a glance how the helm is at any moment without requiring to ask the steersman. A powerful Marconi wireless installation forms part of the equipment.

Deck Machinery and Cargo-Handling Appliances.

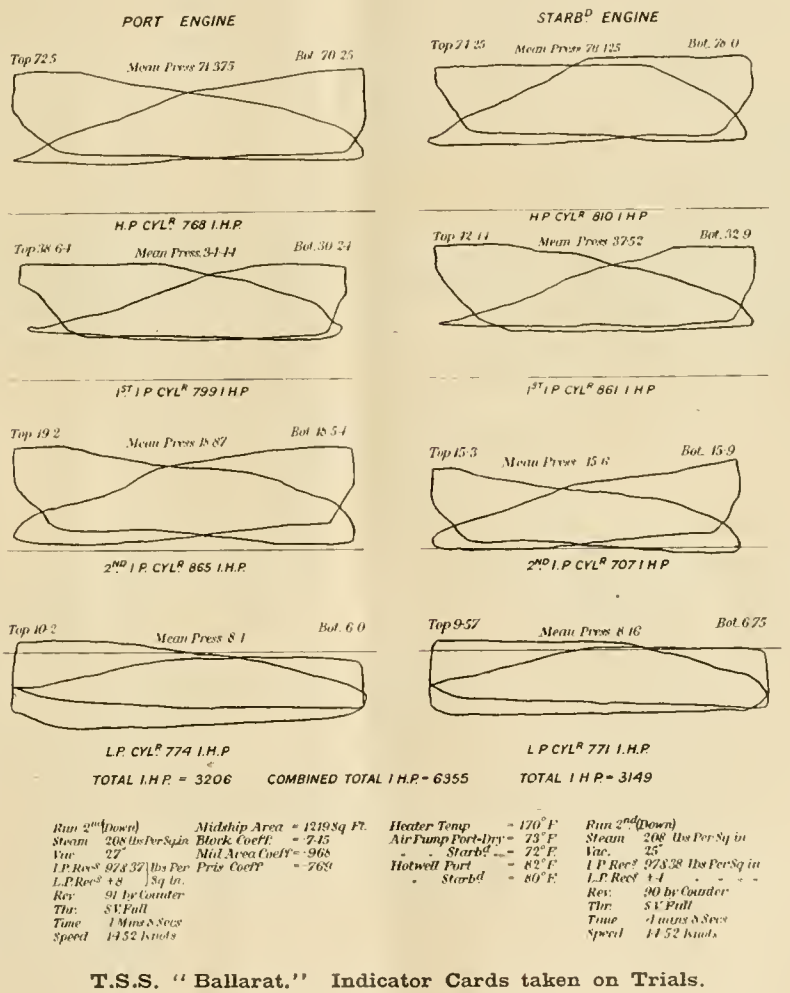
The steering gear consists of Brown Brothers' steam tiller, fitted in a special house on the shade deck aft, and controlled from the wheelhouse on the bridge by telemotor. An arrangement is fitted whereby the tiller can be worked by the warping capstans in case of a breakdown of the steam steering gear. The deck gear for handling the cargo consists of 25 steel derricks designed for loads from 3 to 30 tons, worked by 24 steam winches, the latter being supplied by Clarke, Chapman & Co.

In addition to the usual steam windlass for working the anchors, four large capstans are fitted, two forward and two aft, for warping the ship. Boat accommodation for all on board is provided by 18 lifeboats and 12 semi-collapsible lifeboats worked by Welin's patent davits and lowering gear.

An emergency dynamo of 25 kw. capacity is fitted above the bulkhead deck. This dynamo is connected to lighting circuits which will enable any person to find his or her way about the vessel in an emergency, and it also supplies at such a time, current for the watertight doors, wireless telegraphy and a two-throw emergency bilge pump, which pump, driven by a submersible electric motor, can be brought into action immediately and suction applied to any flooded compartment.

Auxiliary Machinery.

All pumps are independent of the main engines. The air pumps being of Weir's "Dual" type, and the centrifugal circulating pumps of Watson's make, are driven by compound engines. There are three feed pumps, a direct-contact feed-water heater, two evaporators for feed make-up, and auxiliary feed and hot water pump, ballast, bilge and sanitary pumps, and a fresh-water pump, all of Weir's make. A Clarke, Chapman duplex pump is also fitted for supplementary sanitary and deck service and for the water supply to See's ash ejectors, two of which are fitted in the boiler rooms. A duplex main feed filter is also provided and a single filter for auxiliary service. The vessel is fitted with a complete electrical installation, current being supplied by four dynamos each of 50 kw. capacity. The steam section of this installation has been supplied by Shanks, of Arbroath, and the electrical work is by the General Electric Company. There are over 1,200 lights, 33 electric motors, and 13 electrically-operated watertight doors. These doors, supplied by the builders, are operated from the bridge by a single movement of a switch, and an indicator is provided showing the position of each door at any time. A local control is also provided at each door, but a safety device is fitted whereby the door cannot be opened electrically if the compartment is flooded.

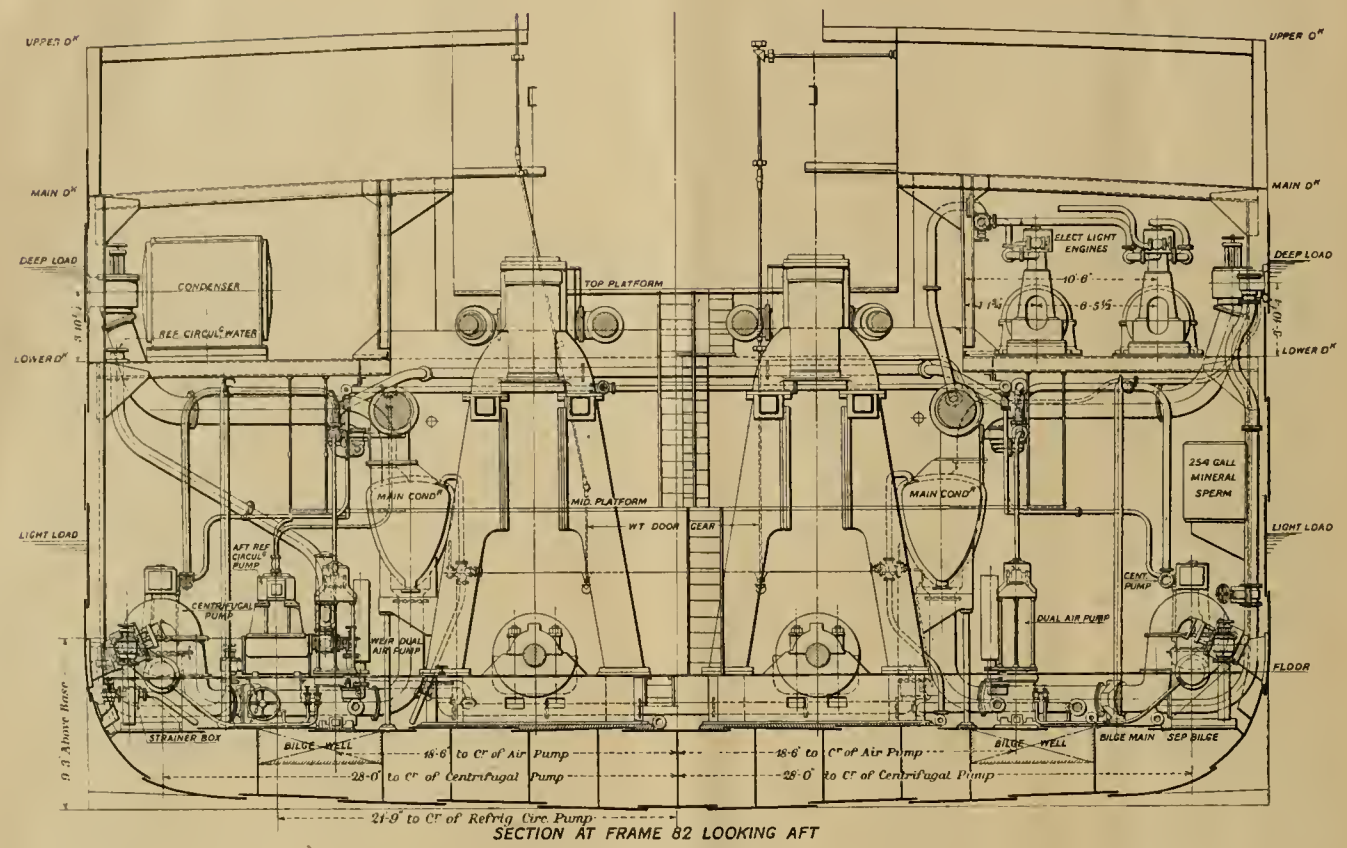


T.S.S. "Ballarat." Indicator Cards taken on Trials.

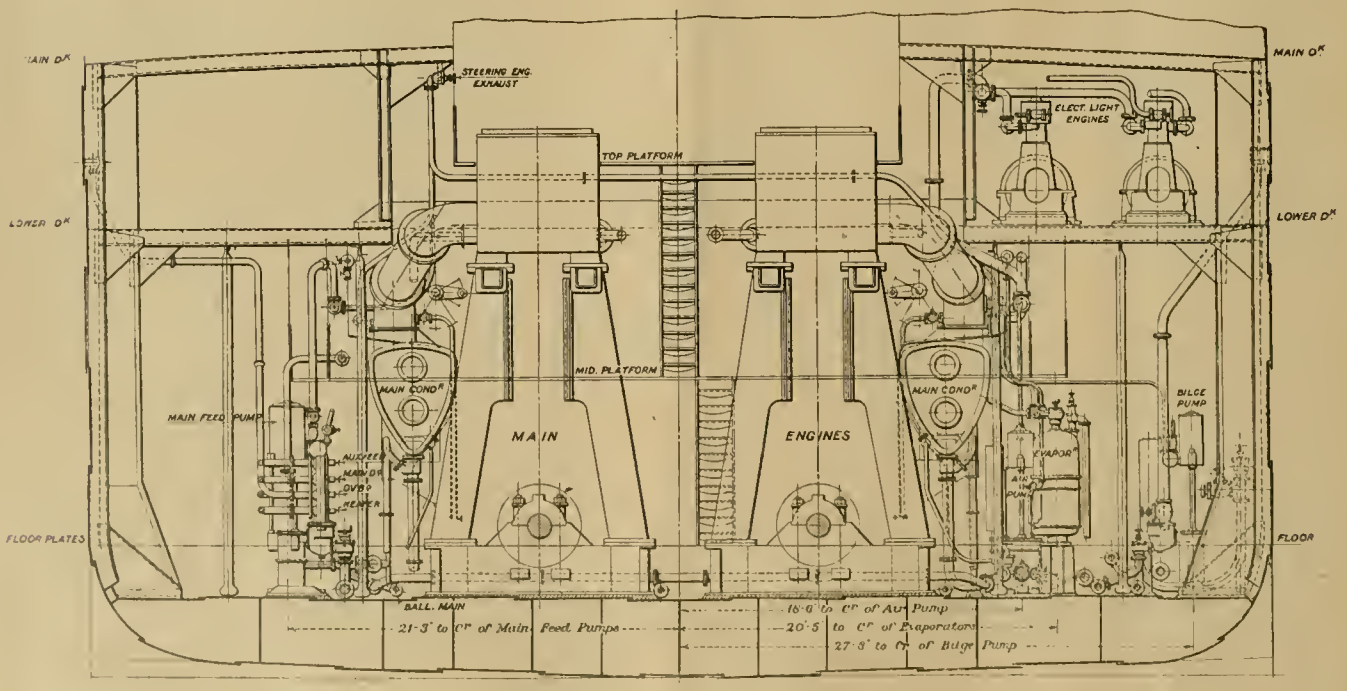
Propelling Machinery.

The propelling machinery of this vessel consists of two sets of quadruple expansion reciprocating engines driving twin screws, and were constructed by John G. Kincaid & Co. Limited, Greenock. The folding plate, reproduced with this issue, shows the port set of machinery. The diameters of the cylinders are 23½ in., 34½ in., 48½ in. and 70 in. by 54 in. stroke, the working pressure being 215 lb. per sq. in. The engines have been carefully balanced, and the cylinders are arranged in the following order from forward to aft, viz.: H.P., L.P., 2nd I.P. and 1st I.P. The H.P. and 1st I.P. cylinders are fitted with piston valves and the 2nd I.P. and L.P. with balanced slide valves, and these are operated by double bar link motion. The reversing engine is of the direct-acting steam and hydraulic type, by Brown Brothers, of Edinburgh. Aspinall's patent governor is fitted. There are six main bearings having circular bushes lined with white metal, and the covers are hollow and arranged for water circulation.

The main condenser is of Weir's "Uniflux" type, has 4,000 sq. ft. of cooling surface, and is suitable for producing a vacuum of 26 in. with injection water at a temperature of 83° Fahr.

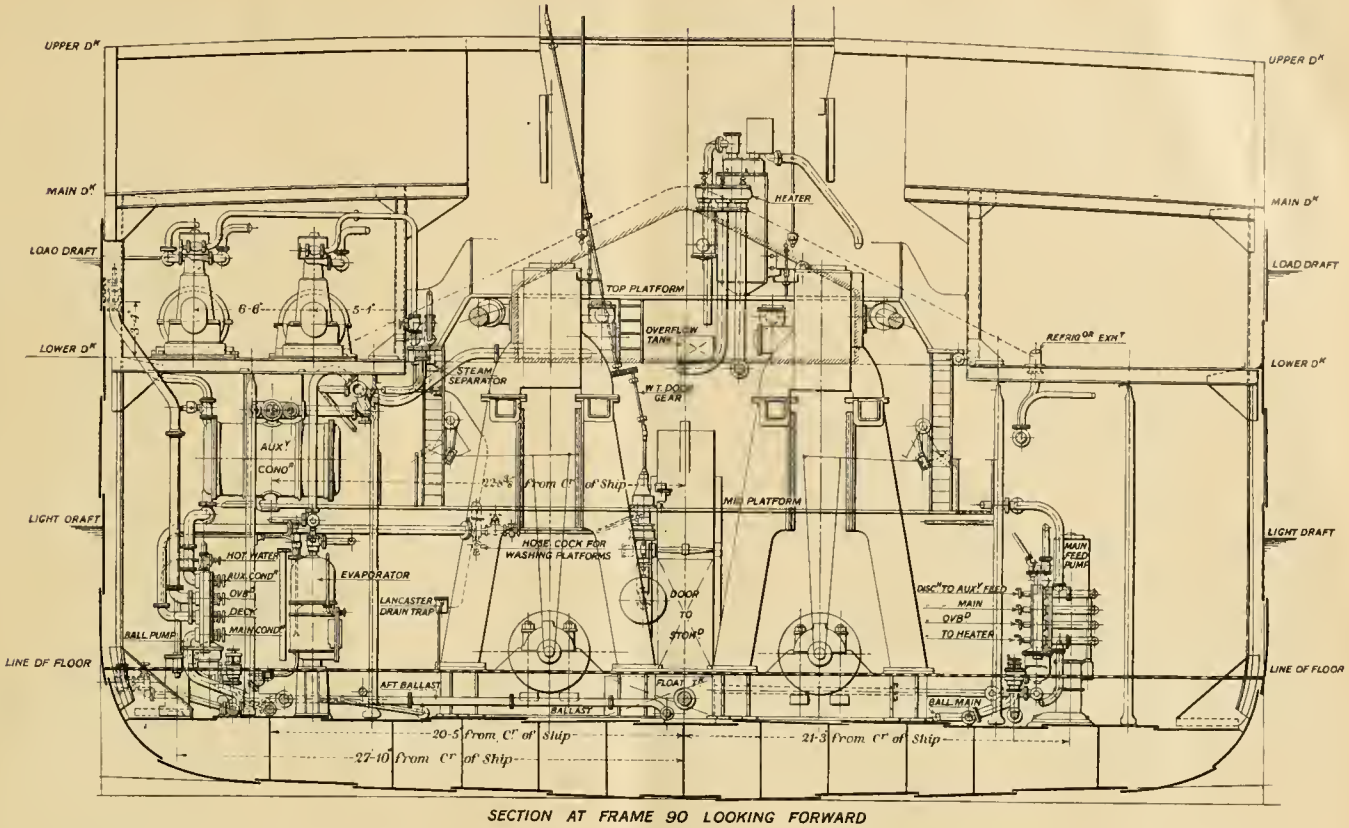


SECTION AT FRAME 82 LOOKING AFT

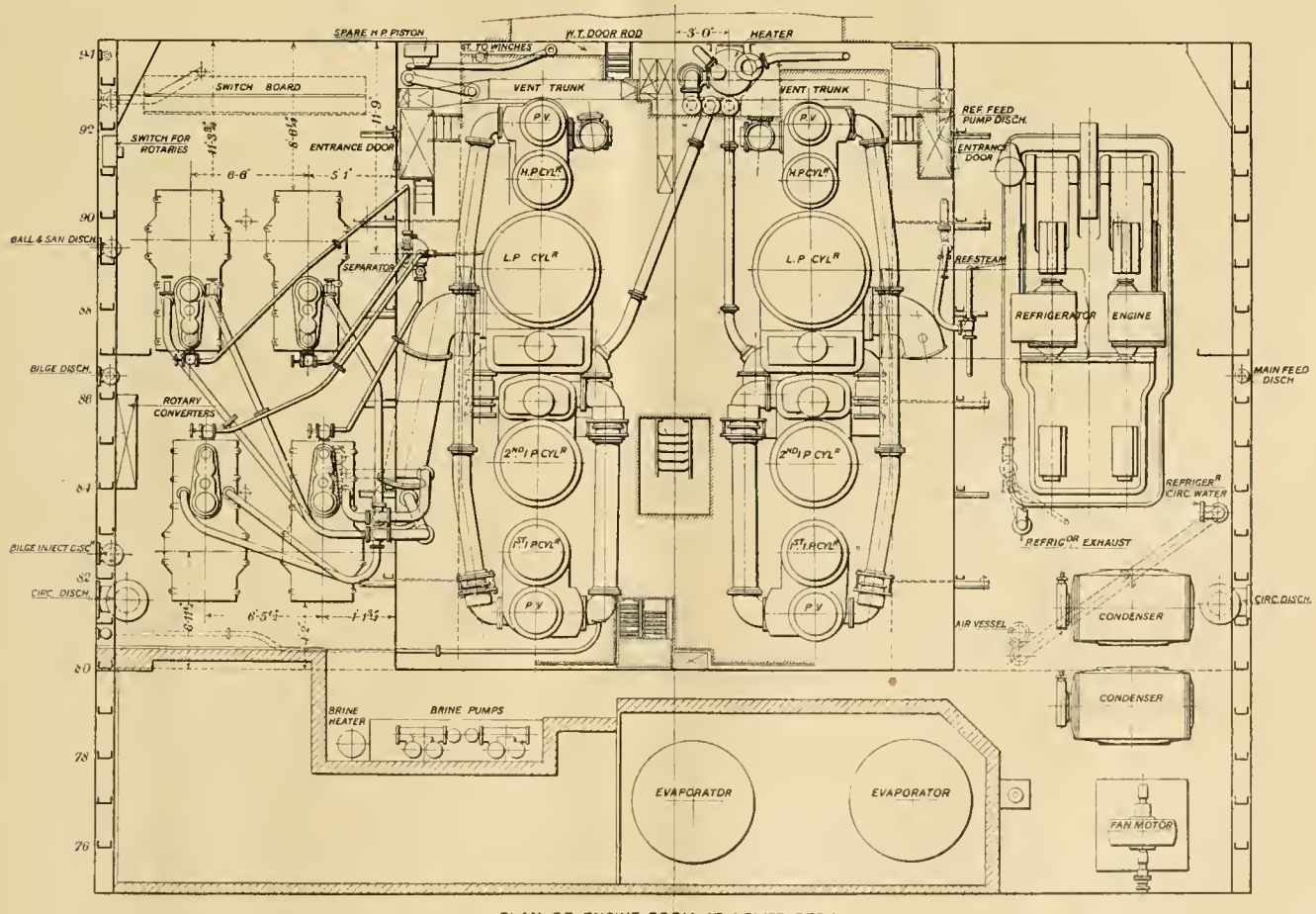


SECTION AT FRAME 88 LOOKING AFT

T.S.S. "Ballarat." Sections at Frames 82 and 88, Looking Aft.



SECTION AT FRAME 90 LOOKING FORWARD

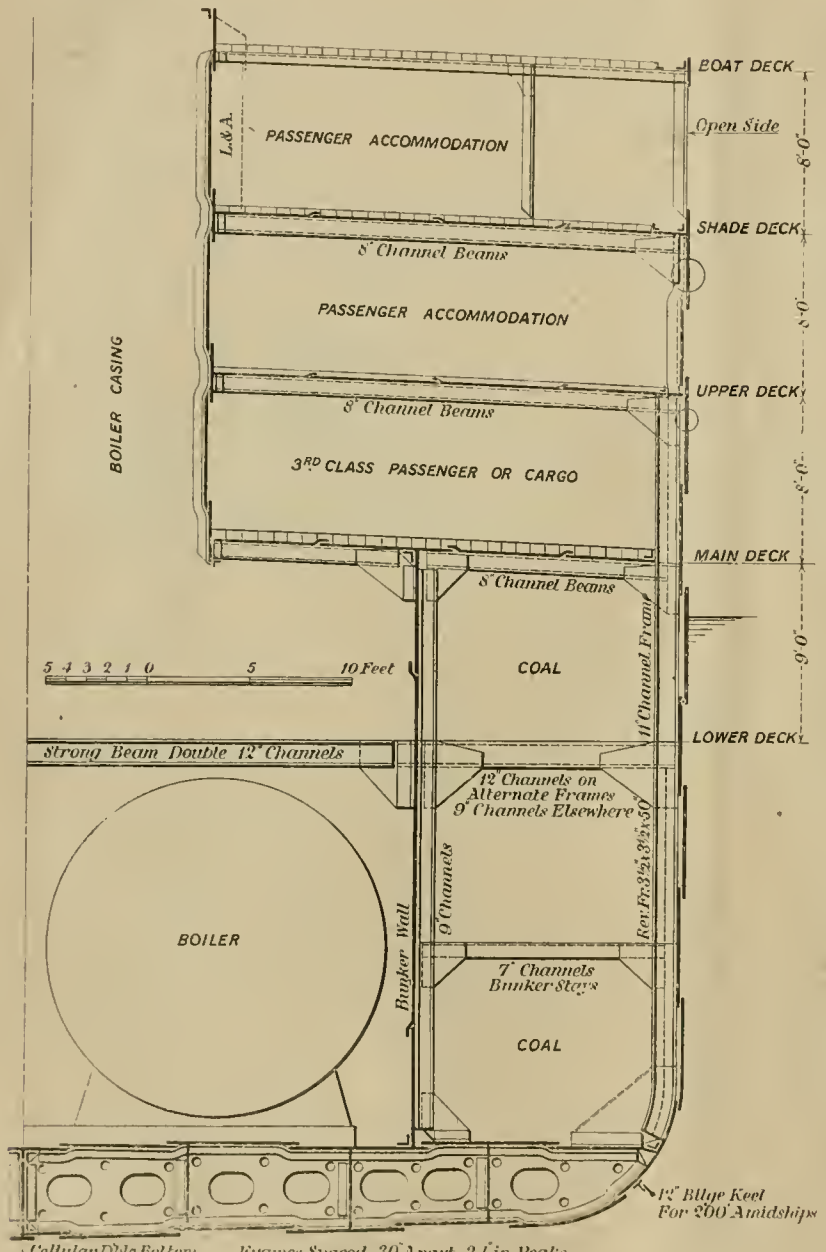


PLAN OF ENGINE ROOM AT LOWER DECK

T.S.S. "Ballarat." Section at Frame 90, Looking Forward, and Plan of Engine Room at Lower Deck.

The propellers have cast-iron bosses, and each is fitted with three manganese bronze blades, with a surface of 72 sq. ft. The diameter of the propellers is 17 ft. 6 in., and the blades are set at 17 ft. 6 in. pitch.

Steam is supplied by five boilers of the ordinary marine type, two being double-ended and three single-ended, and these are arranged in one boiler room. They are of sufficient capacity for 8,000 i.h.p. at 95 r.p.m. All the boilers are



T.S.S. "Ballarat." Cross Section.

16 ft. 6 in. diam., the double-ended being 20 ft. long and the single-ended 11 ft. 8 in. long. The four-furnace arrangement has been adopted throughout, making a total of 28 furnaces, and giving a combined grate area of 513 sq. ft. The total heating surface is 21,320 sq. ft., and the working pressure 215 lb. per sq. in. Parabola furnace bridges are fitted, also "super-circulators" in the water spaces. The Cumberland electrolytic system is installed in the boilers. The boilers work under forced draught on Howden's system, air being supplied by two electric motor-driven fans. Two pairs of ventilating fans are fitted in the engine room, each pair being driven by an electric motor.

Trials.

The *Ballarat* ran trials on the measured mile at Skelmorlie. The draughts forward and aft were 18 ft. 9 in. and 21 ft. 1 in., respectively, giving a displacement of 13,925 tons. On the medium power trial on the down run a speed of 14·52 knots was obtained with a combined total i.h.p. of 6,355, the mean revolutions being 90·5 per minute. We reproduce on page 197 specimen indicator diagrams and trial data relating to this run.

The vessel was designed to meet the special requirements of the P. & O. branch service by the naval architect of the P. & O. Company, Mr. C. G. Deane, and the machinery was constructed to the designs and specification of Mr. Robert Leslie, the Company's superintendent engineer.

DOUBLE-REDUCTION GEARS IN THE SS. "MELMORE HEAD."

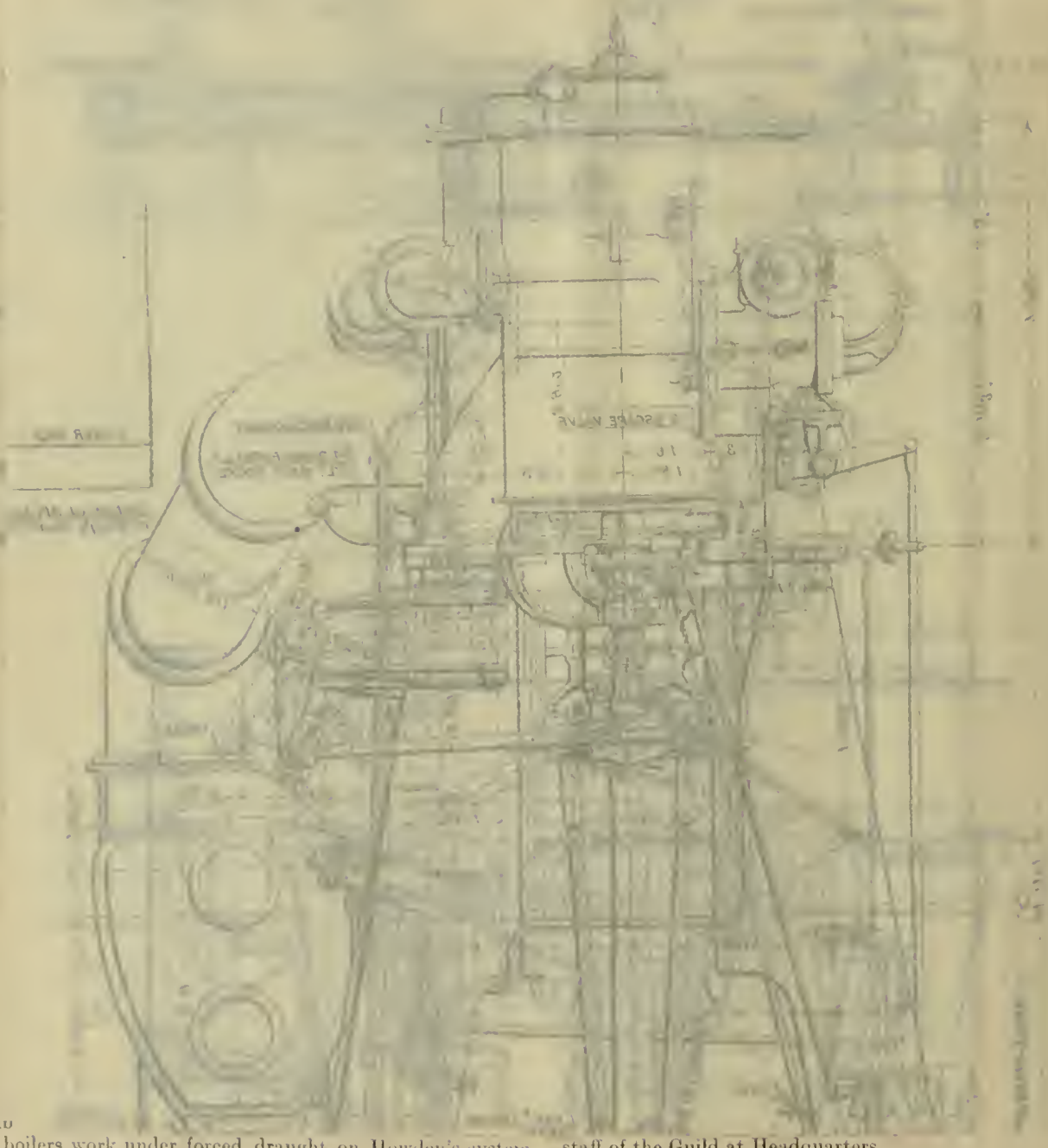
(*Concluded from page* 193.)

With this arrangement the ship has been in continuous service, and is giving complete satisfaction. Up to the time of writing, voyages 12, 13, 14 and 15 have been completed. The average revolutions for the twelfth voyage and the remaining homeward voyages are low, due entirely to the poor quality of coal. The condition of the gearing is perfect. So far no "pitting" has appeared on the primary gears, and only very light "pitting" along the pitch line of the secondary gears, which occurred prior to the carrying out of these experiments and has not developed since. There is absolutely no trace of a beat in the gear case while running up to full power. The second reduction gears have now completed approximately 50,000 miles, 16,000 before fitting the "nodal drive," and 34,000 miles since the experimental work commenced. The writer would like to draw attention to the fact that all these changes in the *Melmore Head* have been carried out in the gear case originally fitted in the ship in 1918. No alterations have been made beyond those already described in the paper, and consequently the continued successful running of this gear is entirely due to the tuning of the periodicities of the various rotating masses of the system.

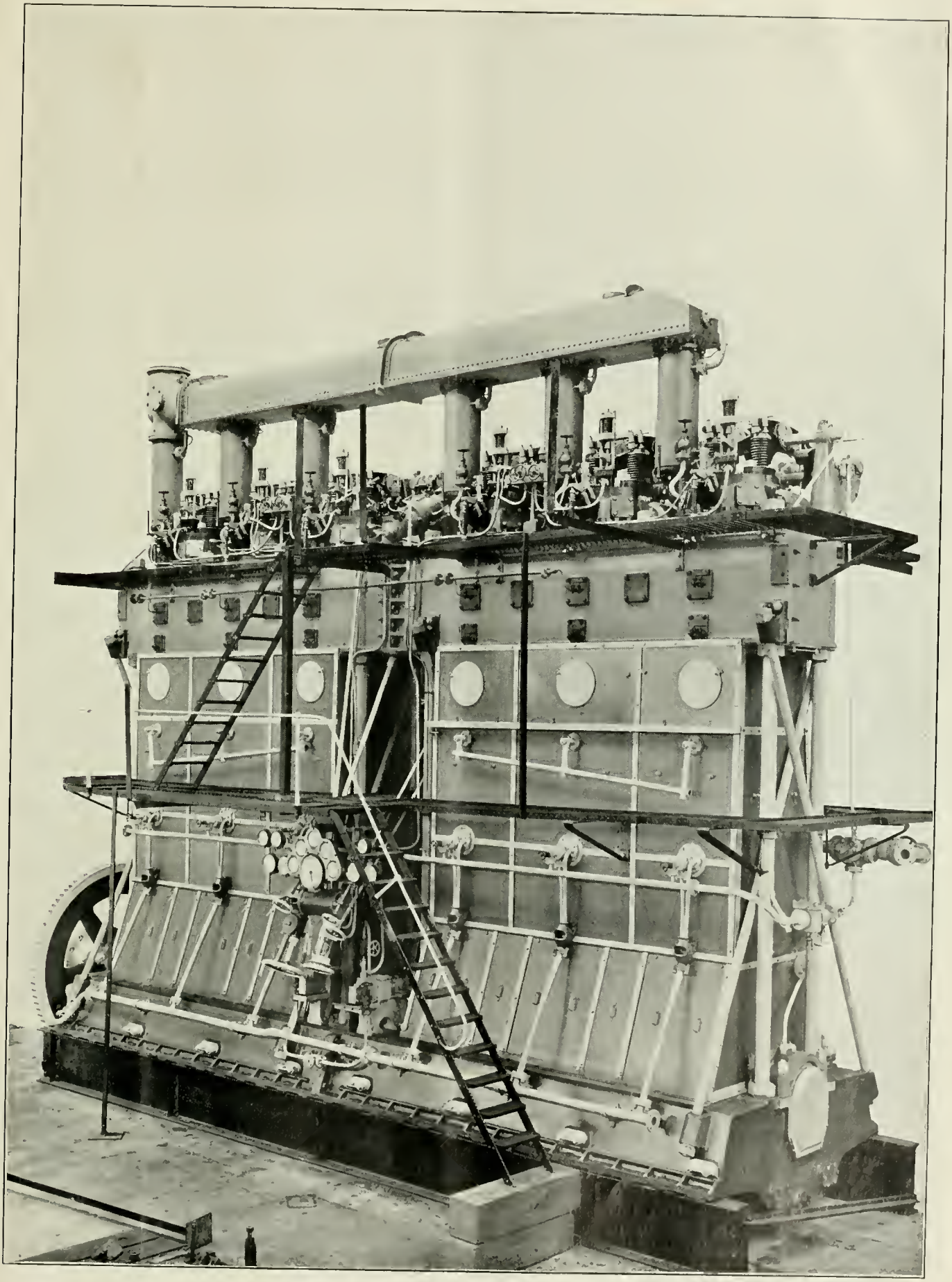
In conclusion, the writer wishes to express his indebtedness to the directors of the Ulster Steamship Company and Workman, Clark & Co. for placing at his disposal so much valuable information regarding the *Melmore Head.*

The death has occurred, at Southport, of Captain F. E. Vincent. He retired about four years ago after having served nearly 20 years in the Harrison Line. There is little doubt but that his untimely end was caused by the strain of his war experiences, his ship, the *Collegian*, being torpedoed when in the Mediterranean. He had been identified for many years with the work of the Imperial Merchant Service Guild, being a member of the management committee for some time, and eventually Vice-Chairman. During the past four years he had been on the staff of the Guild at Headquarters.

INSERT FOLD-OUT OR MAP HERE!



The boilers work under forced draught on Howden's system, staff of the Guild at Headquarters.

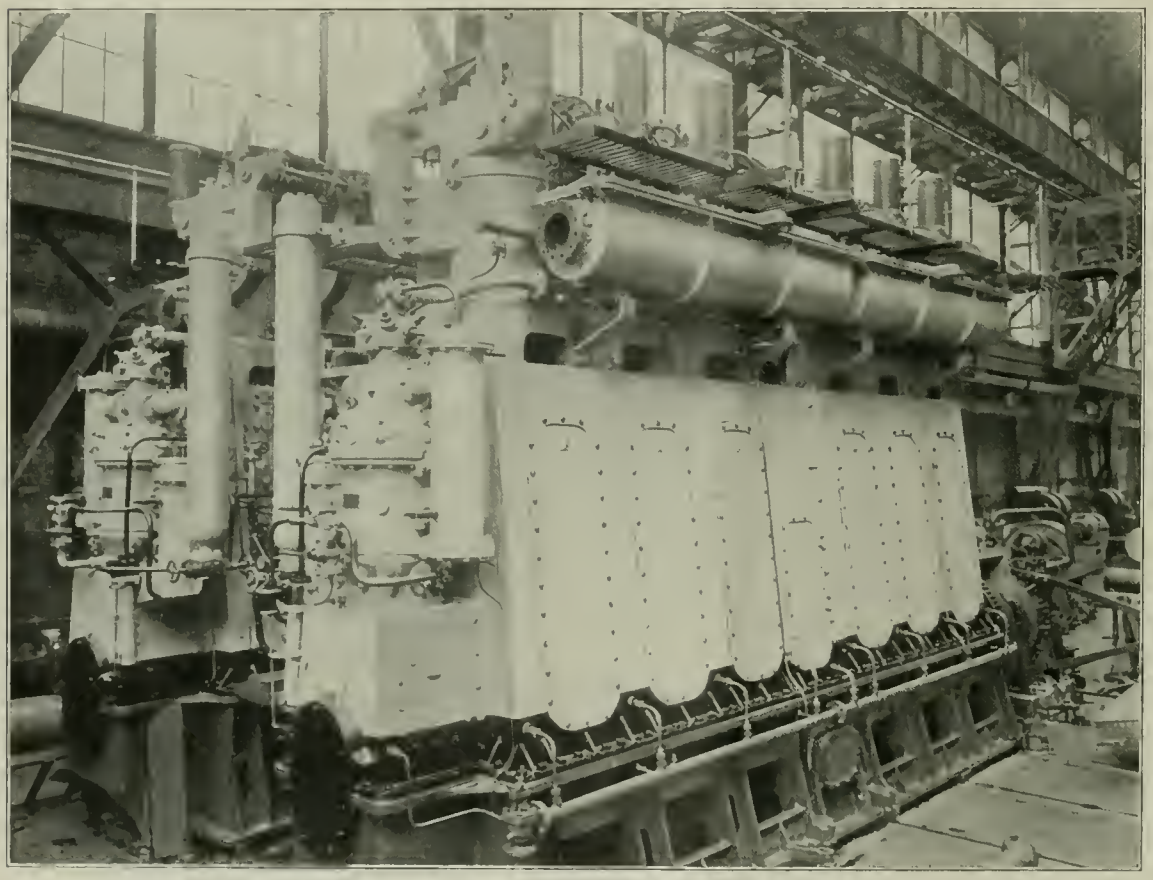


M.S. "Segovia." North-Eastern Werkspoor 4-Cycle Engines, 1,400 b.h.p. at 125 r.p.m. (*See page* 207.)

NORTH BRITISH DIESEL MACHINERY FOR 2,000-TON TWIN-SCREW VESSELS.

Two Sets of Engines for the British India Steam Navigation Company's Vessels, "Dumra" and "Dwarka," developing 500 b.h.p. on each of Twin Shafts, and built by the North British Diesel Engine Works, Glasgow.

By the courtesy of the owners on the one hand, and of the engine builders on the other, we are able to publish some interesting preliminary details of the propelling machinery for the two motor vessels *Dumra* and *Dwarka* at present under construction by Chas. Hill & Sons Limited, at Bristol. The first set of engines has now been completed at Glasgow and is ready for transport to Bristol for installation. Each vessel is propelled by twin screws and has a gross tonnage of 2,000.

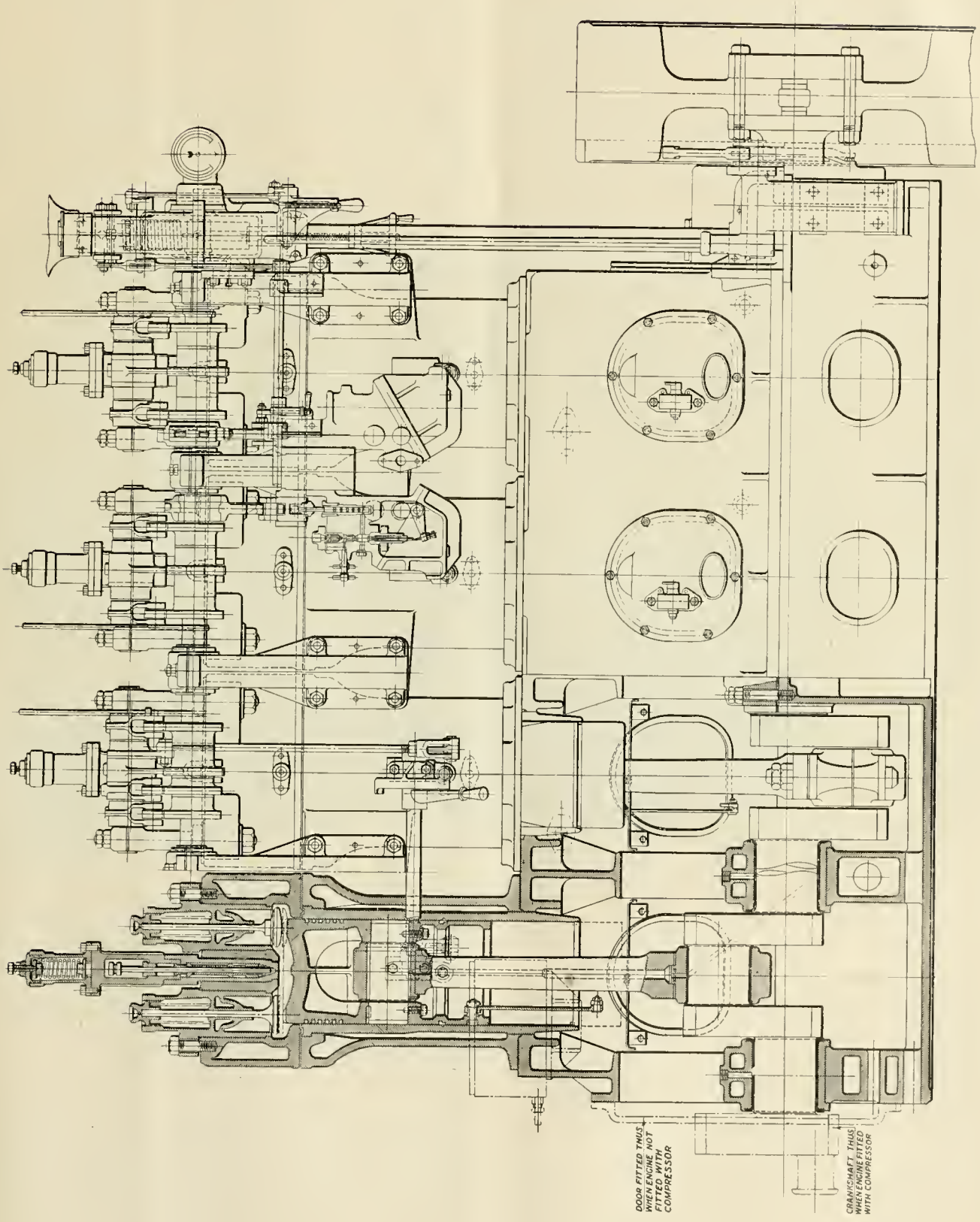


M.S. "Dumra." Twin-Screw, 4-Cycle Engines developing 500 b.h.p. on each Shaft.

General Description of Engines.

These engines are of the four-stroke cycle, marine crosshead type, each set developing approximately 500 b.h.p. in six cylinders, when running at 165 r.p.m. The piston speed is 825 ft. per min., and the engines are entirely enclosed, working under forced lubrication. Each cylinder has a bore of 15 in. and a stroke length of 30 in. We reproduce above a view of the assembled engines for the *Dumra* taken in the engine shop of the North British Diesel Engine Works at Glasgow. A cast-iron crankcase is provided on the top of the bedplate, and on this crankcase the cylinder jacket castings are mounted. It is noteworthy that this represents the largest size of engine that the company propose to design with a crankcase construction. Stuffing-boxes are provided in the upper section of the crankcase, through which the piston rods pass, so that the used oil or carbon products from the cylinder walls cannot gain access to the crankcase, and by this means adulteration of the crankcase lubrication is eliminated.

The connecting-rod top ends are of the ordinary table type, having white metal cast steel top end bushes, the table type of connecting-rod being preferred to the forked type as it forms a more rigid platform for the bearing bushes. The crankshaft is of the entirely built type throughout, being made in two pieces, each of three throws. A built shaft is made possible in this case owing to the high stroke-bore ratio of the engine. The bedplate is of the flat bottom type, arranged to sit directly on the tank top without any special seating being provided. The underside of the bedplate is cast as a trough, and slopes from either end down towards the centre, where an adequate drain is provided to take away the forced lubrication oil which gains access to the trough from the bearings. The cylinder jacket at its lower end, which rests on the top of the crankcase, is made in the form of a bridge in order to give free access to the piston rod gland and the underside of the piston. The cylinder liner is an independent casting, lightly forced into the cylinder barrel and surrounded by a water jacket. The cylinder head or cover is dished up on the lower face, *i.e.*, the face next the combustion space, and pockets are provided fore and aft to accommodate the inlet and exhaust valves. In this way it is possible to provide a very ample space between inlet and exhaust valves for the housing of the fuel valve, a provision which gives a greatly added degree of strength to the cover. Inlet and exhaust valves are of the usual mushroom type, the exhaust valve cage being water-cooled and the exhaust valve being provided with a special, renewable cast-iron face. This practice has been adopted as the result of experience, which has shown that cast iron is capable of resisting successfully the action of high temperature exhaust gases. The fuel valve is of the outward opening type. It is interesting to note that this fuel valve has no stuffing-box, but is provided with a very close-fitting, long, cast-iron sleeve. This sleeve keeps perfectly



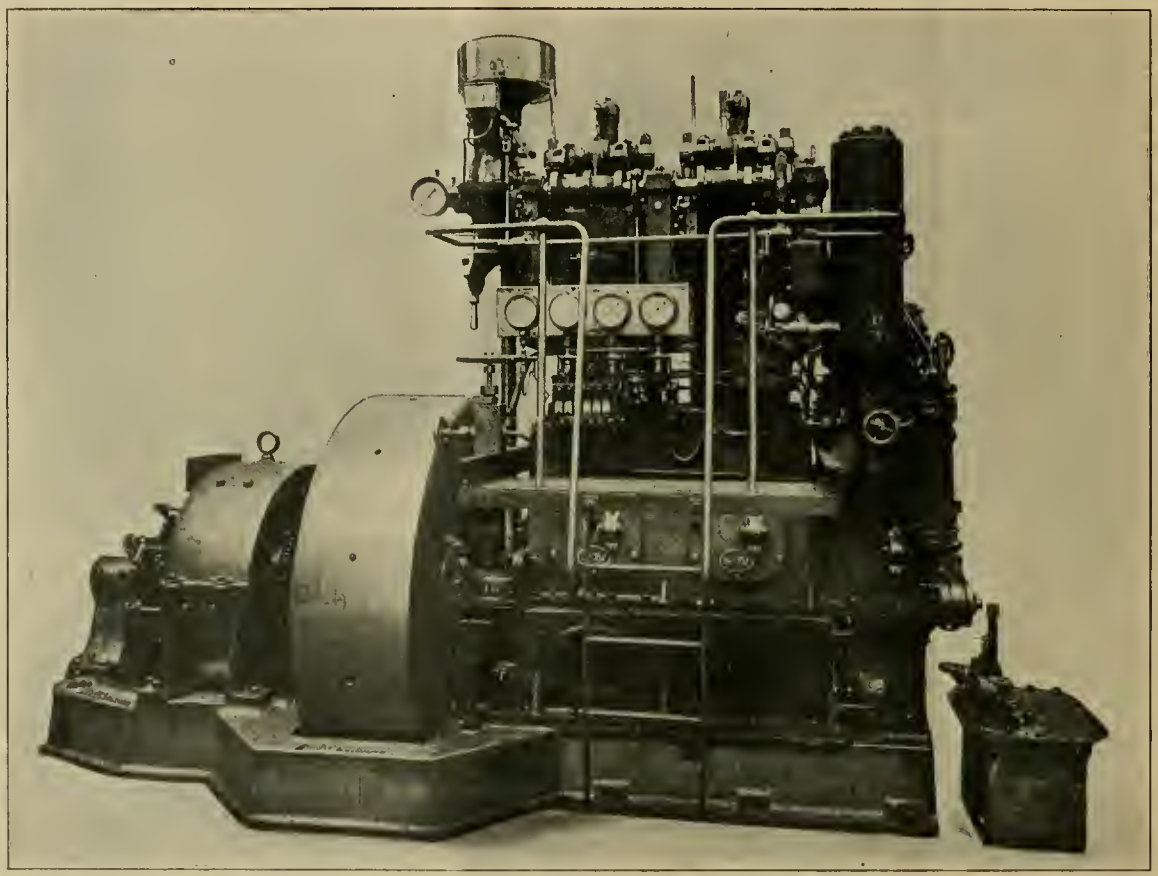
M.S. "Dumra." Sectional Elevation of Typical Auxiliary Diesel Generating Engine.

tight against the injection air pressure of 1,000 lb. and obviates the necessity of frequently repacking the fuel spindles, an operation which gives much trouble to sea-going engineers on Diesel ships.

Starting and Reversing.

Separate levers for the forward and after groups of three cylinders are provided for switching the cylinders on to starting air and fuel, so that the engine may be more easily changed over from air and fuel when frequent manœuvring is called for. The camshaft is placed at the level of the cylinder head and the valves are actuated through the usual cast-steel rocking levers, duplicate cams being provided for ahead and astern running.

The engine is reversed by lifting the rollers clear of the cams and sliding the camshaft endwise. This operation is performed by a direct-acting, air-hydraulic, reversing engine of the Mactaggart Scott type, the engine operating the reverse gear by means of a rack and pinion. Haud gear is also provided with the reversing engine so that the valve gear may be reversed even when compressed air is not available. A separate fuel pump is furnished for each cylinder, the pump bodies being made of blocks of mild steel. As in the case of the fuel valves, no stuffing-boxes are provided for the pump plungers, close-fitting cast-iron sleeves being furnished in their stead. The delivery of the pump is controlled by holding open the suction valve in the usual way.



MS. "Dumra." Two-cylinder Auxiliary Diesel Engine Generating Set.

An Aspinall governor is provided to prevent excessive racing of the engine, and this governor acts on the fuel pump suction valves. On the after length of the engine crankshaft a flywheel is provided which reduces the cyclic irregularity to about 1 in 30. On the rim of the flywheel teeth are provided for double-reduction worm-turning gear, this gear being operated by a small reversible direct current motor.

Piston Cooling and Lubricating Arrangements.

Piston cooling is effected by means of the circulation of lubricating oil. This oil, which is supplied from the forced lubrication system, passes from the main bearings through holes in the crankshaft to the connecting-rod bottom ends. The oil then passes up through the connecting-rod into the piston rod via the crosshead bearings. A tube is provided in a hole in the piston rod and the cooling oil passes up through this tube into the piston, the return oil from the piston being taken down an annulus outside the tube and thence to the crosshead guide face. A trough is provided at the bottom of the guide face to collect the cooling discharge from the pistons, and a pipe is led from this trough outside the crankcase and into a funnel at the starting platform to act as a tell-tale, thus enabling the engineer on watch to observe if an ample supply of oil is coming through the pistons. Cylinder lubrication is provided by a battery of Empire lubricators placed at the engine platform.

Auxiliary Machinery.

On this page will be found a photograph showing one of the auxiliary Diesel engines, and a sectional view of a similar, but four-cylinder, engine is shown on page 205. Two of these Diesel-driven electric generating sets are provided for the supply of current at sea and in port. In the *Dumra* the auxiliary engine is of the two-cylinder type, with a cylinder bore of 11½ in. and a stroke of 14½ in. The normal revolutions are from 325 to 375 per minute, and at the higher revolutions each engine develops 100 b.h.p. Among the principal electrically-driven auxiliaries are the following:—

Steering gear.	Two cylinder cooling pumps.
Windlass.	Two lubricating pumps.
Stand-by compressor.	Two bilge pumps.
Ballast pump.	Fresh-water pump.
Oil fuel pump.	

In addition to the electrical auxiliaries, a large "Cochran" boiler, 8 ft. diameter by 16 ft. high, is provided for supplying steam to the cargo winches. This boiler has a heating surface of 850 sq. ft. and works at a pressure of 100 lb. per square inch. It is situate in a recess at the forward end of the engine room. The exhaust gases from the main engines pass into water-cooled manifolds at the back of the cylinders, and from there are passed by means of cast-iron pipes with extension bends into the main silencer arranged inside the funnel.

In the engine room are provided the usual working air

(*Continued on page* 207.)

M.S. "SEGOVIA."

Built by Wood, Skinner & Co. Limited, Bill Quay, Newcastle-on-Tyne, and engined by the North Eastern Marine Engineering Company Limited, Wallsend-on-Tyne.

The *Segovia* is a steel screw motor vessel built by Wood, Skinner & Co. Limited, to the order of Otto Thoresen's Linie, of Christiania, Norway. The principal dimensions of the vessel are :—Length, 270 ft. ; breadth, 37 ft. 8 in. ; depth to combined bridge deck, 25 ft. 6 in. ; and she is capable of carrying over 2,000 tons deadweight on a moderate draught of water. The vessel is of the single-deck class, with a combined poop, bridge and topgallant forecastle. The vessel has been specially designed for the fruit-carrying trade, and is fitted with four hatches and the most modern improvements for the handling of cargo, including double steel, tubular derricks to each hatch and seven powerful electric winches. A Hele-Shaw Martineau electric-hydraulic steering gear with telemotor control, and an electric windlass, are also fitted. The cellular double bottom is arranged to carry oil fuel throughout, and a special reserve tank is also fitted as required by the Norwegian authorities.

Description of Engines.

The main engines, which have been supplied by the North Eastern Marine Engineering Company Limited, a photograph of which will be found on page 203, are of the four-cycle, single-acting, reversible, crosshead type, of the North Eastern Werkspoor design. There are six cylinders each of 560 mm. bore by 1,000 mm. stroke, which develop about 1,400 h.p. when running at a speed of 125 r.p.m. The auxiliaries required in connection with the main propelling machinery are all driven direct from the engines by means of the usual pump levers. These comprise a three-stage air compressor, cooling-water pumps, two bilge pumps, one of which is used for discharging the piston cooling water overboard, a low-pressure fuel pump for charging the fuel filter, and a lubricating oil pump which transfers the lubricating oil from the sump in the bedplate through a cooler to the gravity tanks situated high up on the forward end of the engine-room casings.

Auxiliary Machinery.

The auxiliary machinery is of the Diesel electric type throughout, the more important comprising two 150 b.h.p. three-cylinder four-stroke North Eastern Werkspoor Diesel motors, each of which drives an electric generator of 100 kw. capacity, one being fitted at each side of the vessel. In addition, the port side motor also drives the auxiliary compressor which is of the Reavall quadruplex type. Arrangements are made on the switchboard connections to enable also the electric generator of this set being used as a motor for driving the auxiliary compressor. For sea use two 12 b.h.p. Kromhout motors are fitted, which drive electric generators, one of which is for supplying current to the steering gear, and the other for ship's lighting, &c. The remaining part of the machinery installation includes an electrically-driven Carruthers ballast pump, with worm drive, an oil fuel transfer pump of the Rotoplunge type, a spare combined set comprising two pumps for lubricating oil, bilge and cooling-water duties, and also includes an emergency two-stage air compressor, a small donkey boiler of 150 sq. ft. heating surface, with feed pump for heating purposes, a lathe and drilling machine, and two Delaval oil purifiers, one for lubricating oil and the other for dealing with oil fuel.

A point worth noting as illustrating the simple nature of this type of machinery is that during the later stages of the fitting out of this vessel, which took place during the present lock-out of the Amalgamated Engineers' Union, the work was completed entirely by apprentices, to whom great credit is due for the interest and energy they displayed in their work.

Performance of sister vessel "Sevilla."

It may be mentioned that the m.s. *Sevilla*, which was put into service in November last, is practically a sister ship of the *Segovia*. The daily consumption of fuel is only 3½ tons, and according to a recent report she had, up to the end of March last, been in continuous service for four months and fourteen days, and had completed 11,738 miles on a total consumption for all purposes of only 234 tons of oil fuel. This includes for port use, also for the loading of four cargoes, and discharging of five by the ship's own winches, and, taken over the whole distance, averages 50 miles per ton of fuel. The fuel consumption works out at the remarkably low figure of 0·33 lb. per i.h.p. per hour. Other points worth mentioning are that there have been no involuntary stops of the machinery, and the vessel has more than once assisted steamships in the Norwegian fjords by taking the lead and breaking her way through icefields.

North British Diesel Machinery—(*concluded from page* 206).

bottles, starting air tanks and daily service fuel tanks, the working or injection air compressor being designed to deliver air up to 1,000 lb. per square inch. The starting air pressure is 350 lb. per square inch, two large cylindrical tanks being provided for this purpose. Duplex daily service fuel tanks are provided, each carrying a sufficient quantity of fuel for twelve hours running at full power. Thrust blocks of the Michell type are furnished, and the propellers are of the three-bladed type, the boss and blades being cast together of solid bronze.

Acceptance Trials.

In accordance with owners' requirements, a 24-hours' acceptance test was carried out on the main engines at Glasgow, and the following are records taken during the trial :—

R.P.M.		165
M.I.P.		104·8
I.H.P.		690
B.H.P.		502
M.E.		72·8 per cent.
Pressures—		
Starting air	350 lb.	per square inch.
Blast air	1,000	,, ,,
Lubricating oil	16½	,, ,,
Circulating water	17	,, ,,
Compressor—		
First stage	52	,, ,,
Second stage	250	,, ,,
Temperatures—		
Atmosphere		62 deg. Fahr.
Circulating water		44 ,,
Brake discharge		120 ,,
Lubricating oil inlet		87 ,,
Lubricating oil outlet		98 ,,
Piston outlet		125 ,,
Circulator Outlet—		
No. 1		112 ,,
,, 2		111 ,,
,, 3		108 ,,
,, 4		109 ,,
,, 5		120 ,,
,, 6		104 ,,

The results of these trials were regarded as highly satisfactory, there being no tendency in any part of the engine to overheat. A complete absence of vibration, even at speeds in excess of the normal full load rating, was observed, and th exhaust gases are stated to have been quite invisible.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Shipyard Lay-out.

With the increased cost of labour, greater attention must be given to the design and distribution of shipyard machinery. The tendency must be towards the development of machinery not only of greater power than heretofore, but also of more automatic action, to ensure greater accuracy of working. German shipyard machinery makers have given considerable attention to the subject, and in this article Oberingenieur Loof, of Messrs. Schiess, of Dusseldorf, considers the application of his firm's machinery and experience to the lay-out of two different types of shipyard. The first is a three to four-berth yard for ships up to 12,000 tons deadweight, and the second a large six to eight-berth yard, capable of building the largest size vessels. The fundamental principles of Taylorism, such as routing, have been specially borne in mind. The path of the material from the store to the ship is carefully detailed, the principle of minimum transport being adhered to throughout. One particular point of interest is that batch drilling is recommended for multiple work. In the smaller yard the platers' shed—or its prototype in Germany—is divided into two main bays, one for the working of bars and the other for the working of plates. In the larger yard, where a larger variety of type is undertaken, the shed is divided into six main bays, the first containing space for the preliminary treatment—*i.e.*, rectification, &c., of material, and the scrive boards. The second contains the angle smiths' and welders' shops. The third is used for the preparation of frames, the fourth for the cold working of angle bars, &c., the fifth for the preparation of light plates, and the sixth for the preparation of heavy plates. In the seventh, preliminary work carried out in the fourth, fifth and sixth is finished off. Each type of yard is described and illustrated.—*W. Loof, Werft, Reederei, Hafen*, April 7, 1922, p. 196; 4 pp.; 2 ff.

Experience with Concrete Ships.

In this article the known and published experience with concrete ships is reviewed. The American Concrete Institute have recently stated that concrete vessels are not cheaper and easier to build than steel ships, are certainly more liable to damage, and finally, the Institute has definitely decided that concrete is not a suitable material for ship construction, especially in view of its heavy weight. Other authorities are more optimistic, and believe that the concrete hull weight—which in the large American ships amounted to 100 per cent. more than the corresponding steel hull—can be reduced in the case of a 3,000-ton deadweight vessel to only 50 per cent. greater than the steel hull. The porosity of light concrete greatly increases its weight, due to absorption of water. In one case where a concrete schooner was sunk, upon raising it and pumping out an increase in draught of 8 cm. was experienced. In view of this heavy hull weight, concrete vessels will merely survive as bulk freight carriers. The stability of concrete vessels can be very small, due to the heavy superstructure generally carried. The case of the ss. *Götaelf* is of special interest in this connection. Due to insufficient stability, the deadweight of 800 tons was reduced by 50 per cent. by having to carry permanent iron ballast. With regard to the resistance of concrete vessels, it has been repeatedly shown that this is less than the corresponding resistance of the equivalent steel vessel, in spite of the greater wetted surface of the concrete vessel. Whether further improvements will take place is a matter for conjecture. Other results of actual running experience with such vessels as the *Götaelf* are to be given shortly.—*P. Wernecke, Deutsche Schiffbau-Zeitung*, November, 1921, p. 241.

Compressed Air in Shipyards.

Although used for over a century in mining work, compressed air has been only used in shipyards for the last 30 or so years. The first pneumatic hammer and caulker was invented by a German, but the manufacture of the product was only taken up at first in the United States. After some years of American monopoly, manufacture was commenced in Germany by the Frankfurt Maschinenbau-Aktien-Gesellschaft, which firm has greatly contributed to the present perfection of pneumatic tools. In the use of compressed air, economy must be practised in its production and subsequent utilisation. Improvement in compressor design has been largely brought about through greater knowledge of the thermodynamic properties of air; and now, depending upon the quantity of air required, efficient single stage, double stage, and turbo-compressors are obtainable. The article describes some of the more important of these compressors, and their respective outputs and efficiencies are also discussed. Considerable loss of efficiency can be suffered, due to leakage in the distribution system—for short leads, 10 per cent., but for long leads as much as 50 per cent. may be lost. The shipyard manager must pay very careful attention to this leakage question. The various types of hammers, caulking and drilling machines, are next considered, with especial regard to their application for shipbuilding purposes, and several recent improvements are discussed, which promise to effect appreciable saving when applied to ship construction. The article deals very completely with the subject, and is well illustrated.—*Prof. J. Kollmann, Schiffbau*, March 1-8, 1922, p. 699; 17 pp.; 10 ff.

Cranes for Shipbuilding and Marine Engineering.

This article forms a very complete review of the potentialities of German constructional steel work, applied to the transport and erectional problems of shipbuilding and marine engineering. The steady growth of ships and their engines has necessitated a corresponding development in crane construction. In this article the various requirements for different applications are separately considered. First, the transport problem in material storage is reviewed, and details of actual cranes in use for this purpose are illustrated. Next, the question of material transport in the platers' shed is considered, and similar illustrations are given. The various types of building berth cranes are next reviewed in considerable detail, and most of the successful designs at present in use in Germany are copiously illustrated. Finally, the giant sheer legs and hammer-head cranes used for outfit purposes are dealt with, and here, again, most of the important German cranes are illustrated and described. A special part of this final section is devoted to the question of floating cranes. Throughout the article, most of the illustrations refer to the work of the Deutschen Maschinenfabrik A.G. Duisburg. In an appendix to the article most of the more important published references to this subject are given. The article forms a useful contribution to the literature of the subject.—*Prof. Kessner, Schiffbau*, March 1-8, 1922, p. 645; 24 pp.; 42 ff.

Design of Scotch Boilers.

In a useful article the author goes through the technical steps usual in boiler design. A given case is taken of stipulated hourly output, working pressure and superheat. The heating surface is first found, after which the coal required and grate surface is approximated to. Next, the superheater surface is determined, and from these main particulars the principal dimensions are obtained. The number of smoke tubes, dimensions of superheater, are next decided upon, and finally the influence of forced draught is investigated. The article deals with each step in the design, and is of interest, inasmuch as it is based entirely on continental methods and data.—*J. Sanszen, Scheepsbouw en Scheepvaart*, April, 1922, p. 65; 4 pp.; 1 f.

Cable Gantries.

The introduction of the cable gantry into shipbuilding solved two problems—the best arrangements of hoisting facilities, and second, a simple means of covering the berth in case of wet weather. This system is easily the cheapest of all gantry systems, and was first introduced into Germany in the Reihevstieg Shiffswerft, at Hamburg, in 1908. The satisfaction of this firm in the system was shown by their extending in 1918 the system to two new berths. Considerable improvement has been effected in the associated hoisting and transporting gear in the new installation. The working speed has been increased, the number of motors and the total weight of traveller reduced. A detailed description of the installation is given. The most modern example of this system is that recently fitted at the Deutsche Werft, at Hamburg, the cables having a span of 500 metres. In this case, at the time of the erection (1919-20), it would have cost four times the amount to construct the ordinary gantry with closed-in roof, and delivery could not have been obtained in the desired time. Full particulars of the installation at the Deutsche Werft

complete the article.—*M. Bruckmann, Schiffbau*, March 1-8, 1922, p. 669; 7 pp.; 10 ff.

German Shipbuilding Research.

There has been recently formed in Germany a company which is to assist, financially and otherwise, the work of the Hamburg Experiment Tank. The company embraces many influential shipowning and shipbuilding authorities, who have recognised the necessity for and the utility of scientific research in ship-designing problems. The importance of this research was first practically recognised by the Norddeutschen Lloyd, who constructed the first tank in Germany at Bremerhaven, in 1899. In this tank much scientific and commercial work has been carried out for all countries, and such famous vessels as the *La France*, the *Imperator*, and the *George Washington*, were designed from the findings of this tank. Other tanks are the Berlin Tank and Admiralty Tank, at Marienfelde. The only private tank is that owned by the Dresdner Company, at Mebigau. Owing to harbour extension, the Bremerhaven Tank has had to be dismantled, and a new tank has been built in its stead at Hamburg. This Hamburg Tank was built by the Hamburg State, and was completed in 1915. The purpose of the experiment tank is briefly, as far as ocean-going steamers are concerned, to develop economical and simple ships, which can utilise the most efficient high-speed Diesel and other engines. For canal vessels such questions as canal breadth and depth require further investigation, in addition to the similar problems of ocean-going steamers.—*Dr. R. Foerster, Werft. Reederei, Hafen*, April 7, 1922, p. 206; 2½ pp.

The Durand-Mattei Marine Boiler.

The superiority of the water-tube boiler over the ordinary cylindrical type with regard to circulation of water and absence of heat stress is well known. The type of boiler built by the Durand-Mattei Company and described by them in this article is of a mixed smoke tube, water-tube type. The smoke-tube portion is at the front of the boiler and is identical in design with the ordinary cylindrical type. The rear portion is identical with the ordinary water-tube type. The detail construction is difficult to describe without a sketch, but briefly the action is as follows. The flames in the combustion chamber act direct on the water tubes connecting the upper and lower collectors. This causes the water to rise in the tubes and immediately produces active circulation which is, moreover, assured by the fact that the smoke-tube temperature is less than that of the water tubes, the smoke tubes being primarily for the exhausting of the flue gases. The installation has been fitted recently in a tug and information as to the performance is supplied. The trial lasted 2½ hours, 9·55 lb. of steam were produced per lb. of coal burnt, and 12·8 lb. of coal were burnt per sq. ft. of grate surface per hour. The boiler efficiency was 78·9 per cent.—*Bull. Tech. du Bureau Veritas*, March, 1922, p. 22; 1 p.; 1 f.

Efficiency of Screw Propellers.

Progress in marine propulsion has been towards the increasing of the efficiency of each unit of the propelling system. The purpose of this article is to show the preponderating effect of the screw efficiency upon the overall efficiency. Good propellers may have an efficiency of from 60 to 65 per cent.; average screws range from 50 to 60 per cent. The limits of model screw experimental results are mentioned and two typical efficiency curves on a base of the Schaffran revs.-thrust constant are given and discussed. The extension of the model methods to the utilisation of data derived from full-sized thrust and torque determination is next discussed, and results of the trials of an English tank are quoted in which a propeller efficiency of 52 per cent. was measured at a speed of 11 knots. Finally, the considerable savings which can be effected by increased propeller efficiency in fuel consumption and reduced weight are brought out forcibly by the author.—*Scheepsbouw en Scheepvaart*, April, 1922, p. 71; 2 pp.; 3 ff.

Freeboard of Ships.

This article forms one of the most comprehensive treatments of the subject of freeboard of ships which has been published in the technical press. The terminology of the subject is first commented on and then the general problem of freeboard is outlined. The historical development is then traced in considerable detail over range of time from 1422 to the present day. Existing and proposed freeboard regulations are next contrasted, and the technical differences existing between the present and proposed Board of Trade requirements, the Norske Veritas and Germanische Lloyd's requirements are treated very fully. Special reference is made to the proposed Board of Trade requirements because of their having to form the basis for the international discussion of the subject. The whole of the recommendations of the English commission with regard to standard of strength are repeated and discussed. Finally, the anomaly of the shelter deck is considered at length, and the old method of the determination of its freeboard is contrasted with that proposed by the 1916 English commission. The article is valuable because of the number of useful references to previous continental contributions to the subject.—*A. Van Driel, Het Schip*, Nos. 14, 15, 18, 19, 23, 1921.

Launching Stresses.

Reference is made to previous work of the present author on the subject of the measurement of stress, and the necessity for a reliable strainmeter is emphasised. The most recent instrument used by the author is then described. In principle, it is similar to the Foster strainmeter, the extension being finally represented by the height of a liquid in a measuring tube. The magnification of the instrument is 6,000, but this could be easily increased. The apparatus has been used to determine the stresses on a ship's structure during launching; and a continous record of stress was obtained by taking a cinematograph film of the liquid in the measuring tube. Diagrams are shown of the measurements taken at the launch of the SS. *Koln* (470 ft. in length) on November 12 of last year. Two sets of readings were taken, one instrument being clamped to the shell in the upper 'tween decks and the other in the lower 'tween decks. The measurements were then examined to test if the structure were acting as a beam. From the simultaneous value of the stresses at any point of time during the launch the position of the neutral axis could be calculated. This was done and was found to be in exact agreement with the value calculated by the usual methods. Next, the bending moment curve for the "stern lifting" condition was established, and, from the calculated value of the section modulus, the stress at each of the measuring stations was obtained and was found to be in close agreement with those actually measured. In the upper measuring station a stress of 1·76 tons per sq. in. was measured, whereas by calculation a value of 1·8 tons per sq. in. was obtained. Next, the bending moment in the afloat condition was calculated, but in this case it was found that residual stress was present which somewhat upset the comparison. Allowance was made for this and the results were finally brought into reasonable accord.—*Dr. Siemann, Z. d. V. d. I.*, April 15, 1922; p. 373; 2 pp.; 7 ff.

Critical Speed of Propeller Shafts.

In turbine vessels with a long length of shafting and low revolutions it is possible for the natural period of vibration of the propeller shaft to coincide with the propeller blade impulse period. A blade impulse occurs when a blade passes the stern post; and thus in a single-screw ship with a four-bladed propeller four impulses occur in each revolution, whilst with a three-bladed propeller six impulses occur. It is hence necessary with these propellers so to control the critical speed of the propeller shaft as to avoid its being equal to, or four or six times the normal revolutions respectively, to eliminate resonance. With a high critical speed compared to the number of impulses resonance is not likely, but with a low critical speed resonance may take place during the operations of stopping and starting. It is thus important for a designer to control the critical speed of the shafting, and a formula is deduced in terms of the diameter and length of shafting to gear case, and the rotational inertia of the propeller and surrounding water. This formula is finally expressed in the form of an alignment chart which greatly facilitates the practical solution of the problem.—*W. Kretschmer, Werft, Reederei, Hafen*, March 22, p. 155; 2½ pp.; 4 ff.

Gardner-Engined Lifeboats on "Empress of Scotland."—Norris, Henty & Gardners Limited last month supplied and carried out the installation of two four-cylinder petrol paraffin engines in lifeboats aboard the *Empress of Scotland*, which was handed over to this country in an unfinished state by Germany and has been placed in commission by the Canadian Pacific. The engines are of the well-known Gardner 4-B.C.R. type, which have been so extensively used for this class of work and develop 20 b.h.p. each at 1,000 r.p.m. We are informed by Norris, Henty & Gardners Ltd., that when this ship was handed over under the terms of the Peace Treaty, the lifeboats were equipped with German engines, but these were not up to B.O.T. standard and had, therefore, to be replaced by a Gardner outfit made throughout to B.O.T. regulations.

NEW WHITE STAR LINER "MAJESTIC."

56,000 Gross Tons. The Biggest Ship in the World.

The White Star liner *Majestic*, illustrations of which appear on pages 181-182, is now being finished off at Southampton, from which port she sails on her maiden voyage to Cherbourg and New York on May 10. The *Majestic*, which was christened *Bismarck*, and was to be the pride of the Hamburg-Amerika Line, was purchased from the Reparation Committee by the White Star Line, who thus are now the owners of the biggest vessel in the world.

The main particulars of the vessel are :—

Length, overall	956 ft.
,, b.p.	912 ft.
Breadth	100 ft.
Depth	57 ft.
Gross tonnage	56,000.

The vessel has nine decks, five of which run the full length of the ship, and accommodation is provided for about 4,000 passengers. The boiler casings, instead of being carried up at the centre of the vessel as is usual, are located at the sides, and are joined at the centre at the boat deck. This method permits of a very fine arrangement of public rooms, the three longest rooms, which are situated on the promenade deck, the lounge, palm court and the restaurant being perhaps the largest ever constructed in the superstructure of any vessel.

Some of the individual portions of the vessel are of a record weight: the rudder post and plates total 140 tons, the stern post and brackets are over 300 tons, and the anchors and cables total over 230 tons.

As a precaution in case of fire, the steel bulkheads are coated with a fireproof material, and hydraulically controlled fireproof doors are fitted which will resist a temperature of 2,900° Fahr. The main staircases are so arranged that they can be isolated if necessary. A fire warning can be sent by telephone from numerous places on board to the bridge, in addition to which there are 450 fire alarms distributed throughout the vessel. The latter indicate automatically to the officer on watch the fact that a certain temperature in a compartment is exceeded. A special apparatus for the detection of smoke is also installed which consists of lines of pipe through which air can bedrawn. The entire system is centralised on the navigating bridge.

Machinery.

The propelling machinery is arranged in three engine rooms having a total length of 124 ft., and consists of eight steam turbines of Parsons design, capable of developing about 100,000 h.p. The vessel has four lines of shafting. Interesting features with regard to the turbine are the weight of the low-pressure turbine 375 tons, free length of one blade 2 ft., and the number of all blades in the turbines, amounting to 900,000.

The boiler plant consists of 48 water-tube boilers of the Yarrow type working under forced draught, and representing a total heating surface of about 220,000 sq. ft., with a grate surface of about 4,000 sq. ft. The furnaces burn oil, and the bunkers, originally designed and finished for coal, have been adapted for this fuel. The weight of the complete main engine and boiler plants amounts to 8,500 tons. The fuel consumption is about 5,700 tons of oil on one passage. The pumps supplying the main condenser have a collective output of 22,000 tons per hour, the pipe lines being $3\frac{1}{2}$ in. diam.

The total length of the ventilator turrets and channels of the *Majestic* exceeds 98,000 ft. The refrigerating system for the fresh provisions is steam-driven, the CO_2 engines developing 100,000 calories per hour. A second installation, electrically-driven, is for the forward insulated hold, and develops 60,000 calories per hour. The general heating installation is steam, but the first-class state rooms are heated by electricity.

The electrical plant consists of five turbo-dynamos, each of which develops 288 kw./115 volt at 2,000 r.p.m. The dimensions of the main switchboard are characteristic for those of the plant: the length is 22 ft., the height 8 ft. The collective section of all 32 feed cables, leaving the switchboard, is 15,000 sq. mm., whose connection value is 2,850 kw.: 22 of these main cables are for power purposes, and six are for lighting and four for heating purposes.

The power cables are connected to the motors, representing a grand total of 225 with a collective power of 1,565 h.p.

Besides the electric main generating station, there is an independent Diesel emergency installation of 80 h.p. 19 ft. above the bulkhead deck, which feeds 800 emergency lamps distributed all over the ship, and is also connected to the boat machinery, the navigating and signalling elements and the emergency wireless installation.

CARGO BOAT MACHINERY.—II. (*concluded from page* 177).

as the tramp steamer; in all probability the diameter of the propeller will have been reduced in accordance with the size of the engine.

It may be pointed out here, that the size of the propeller shaft, and, in a measure, the size of the crankshaft, is partially governed by the diameter of the propeller, hence from an economic point of view every separate series of sizes of machinery has a maximum diameter of propeller which should be fitted, this being a regulation of the various registration societies.

The cargo steamer usually has 10 per cent. excess margin of power over the allowance given to tramp steamers, so as to enable it to maintain the speed required in a given trade under average conditions of weather.

It must be remembered that the fitting of smaller engines and propeller often entails the fitting of larger boilers, so that the steaming weight of the machinery is not reduced, but the weight of coal per unit of power that is required may be increased, so that the question of the most efficient size of machinery becomes extremely difficult, and never was so important as it is to-day, especially in view of the fact of the severe competition shipowners will have to meet in the immediate future, particularly from Germany, who have been training their superintendents up to the level of expert consulting engineers since before the commencement of the war of 1914–1918.

Note.—In the previous article of this series, an error appears in the formula in column 1, page 67, due to separating Lloyd's Compound Rule which embraces both engines and boilers. The formula should read as follows :—

$$\frac{W\,P + 590}{1500}\left(\frac{L^2\sqrt{S}}{100}\right)2 = C\,\frac{L^2\sqrt{S}}{200}.$$

At the top of column 2, the rule also requires correction, and should read $\cdot 5133\left(\frac{L^2\sqrt{S}}{200}\right) = \text{N.H.P. of engine.}$

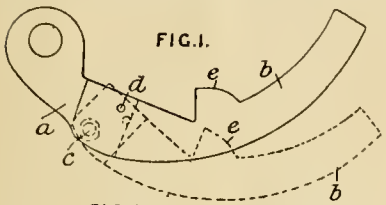
The diagram as given on page 66 is correct as a simple example will at once show.

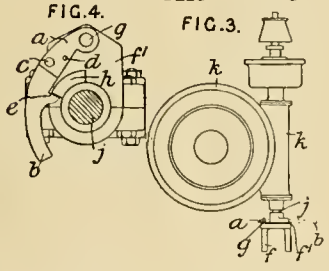
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 172,045. Furnaces.

Ferguson, D., 75, *Bolton Drive, Mount Florida, Glasgow. June* 7, 1920, *No.* 15388. [*Classes* 51 (i) *and* 80 (iv).]

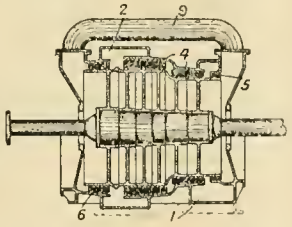




Mechanical Stoking.—A safety link for use with the driving gear of underfeed stokers and of the kind comprising two parts hinged together and secured by a safety-pin which is adapted to be sheared under excessive load comprises members *a*, *b*, Fig. 1, hinged at *c* and secured by a safety-pin *d*, which passes through holes in the overlapping portions of the link, and provided with a projection *e*. The link is pivoted at *g*, Figs. 3 and 4, to the driving member *f*, *f*1, and the projection *e* engages with a projection *h* in the driven member *j* connected to the worm gearing arranged in the casing *k* and connected to the stoker.

No. 172,219. Steam Turbines.

Nederlandsche Fabriek van Werktuigen en Spoorwegmaterieel Jenaamd "Werkepoor," 62, *Oosten burger Middenstraat, and Springer, J. C.*, 464, *Overtoom, both in Amsterdam. December* 1, 1920, *No.* 33923. [*Class* 110 (iii).]

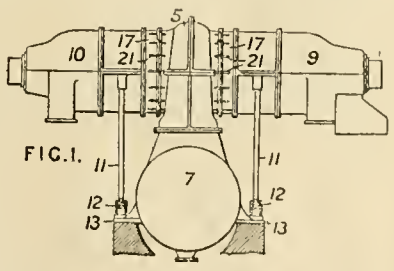


Several pressure stages of an axial-flow turbine are arranged so that the stuffing-boxes on the main shaft are subjected to practically no difference of pressure from atmospheric. The steam inlet chamber 1 and the condenser outlet 2 are both located between the end faces of the rotor and the blading is arranged in two main sets, one set 4 between the inlet 1 and the condenser 2, and the other main set 6 outside the condenser outlet 2.

No. 174,526. Turbines.

British Thomson-Houston Company, Limited, 83, *Cannon Street, London.* (*General Electric Company, Schenectady, New York, U.S.A.*) *January* 21, 1921, *No.* 2807. [*Class* 110 (iii).]

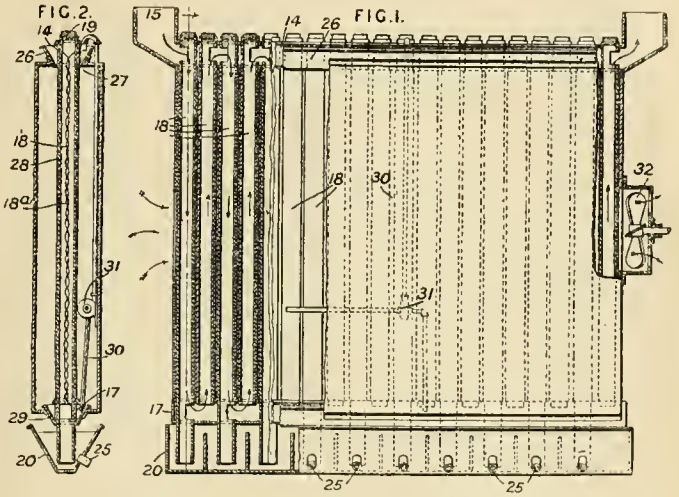
To allow for expansion due to changes of temperature, a portion of the casing of an elastic fluid turbine-driven set is rigidly supported and connected by a separate ring to a resiliently-supported portion, the ring being made of a material which is stronger than the casing material. In one form, the casing 5 of a radial-flow turbine with oppositely-rotating rotors is rigidly mounted on the condenser 7 and is connected by separate flanged and bolted rings 17 to the casings 9, 10 of electric generators driven by the turbine. The casings 9, 10 are resiliently mounted by columns 11 on springs 12 carried on brackets 13 on the condenser casing. The casings are made of cast iron and the connecting rings 17 of cast steel provided with slots 21, which prevent the tangential stresses due to expansion from becoming too great. In a modified form, the flanges of the connecting rings are arranged so that the connecting bolts are within the casings.



No. 172,393. Condensers.

Johns, G. M., 320, *North Grand Avenue, St. Louis, Missouri, U.S.A. September* 2, 1920, *No.* 25392. [*Class* 55 (ii).]

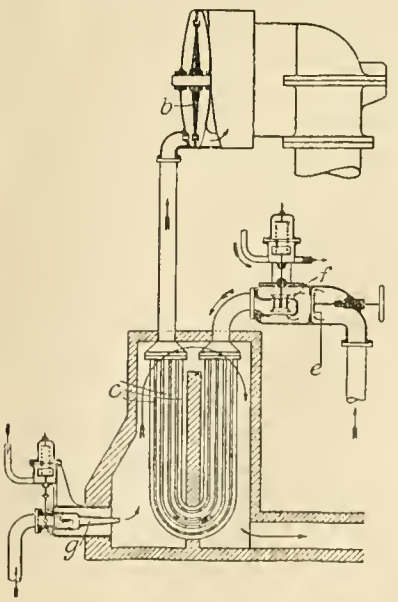
An apparatus for condensing oil and like vapours comprises a series of vertical tubes 18 opening at each end into headers 14, 17, and so arranged that the vapours entering at a connection 15 pass alternately downwardly and upwardly through the tubes, which are covered with fabric 28 moistened with liquid from a trough 26



having perforations 27. The liquid, after moistening the fabric, collects in a lower trough 29 and is delivered again by a pump 31 and pipes 30 to the upper trough. A fan 32 causes a circulation of air through the apparatus to assist in cooling the pipes 18. Each alternate pipe 18 is extended into compartments in a lower trough 20, each compartment having an outlet 25 so that the condensates from each compartment or from a series of compartments may be taken off separately. The top of each tube 18 is closed with a stopper 19 which may be removed for cleaning purposes, and inside the tubes spiral metallic strips or wires 18*a* may be used to give the vapours passing through a spiral motion and bring them into contact with the walls of the tubes.

No. 174,367. Turbines.

Akt.-Ges. Brown, Boveri et Cie, Baden, Switzerland. January 21, 1922, *No.* 1886. *Convention date, January* 21, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

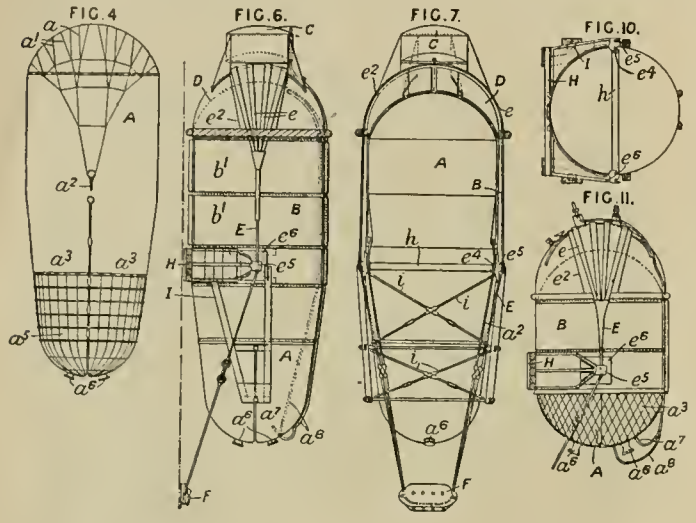


To enable highly superheated steam to be used in a turbine without injury to the stop valves and regulating valves, the high superheater *c* is located between such valves *e*, *f* and the turbine *b*. The fuel nozzles *g* and valves *f* may be controlled by the turbine governor acting through oil-pressure valve gear or otherwise. The waste gases from the superheater are led to the boiler furnace.

No. 175,046. Raising Sunken Ships.

Vickers Limited, and Thurston, Sir T. G. O., Vickers House, Broadway, Westminster. November 6, 1920, *No.* 31457. [*Class* 68 (ii).]

A submersible pontoon for raising sunken ships and other objects comprises a cylindrical air bag A, Fig. 4, with a dome-shaped upper end *a* over which is disposed a network a^1 of wire ropes to which lifting-cables a^2 are attached, and an open-bottomed steel casing B, Figs. 6 and 7, constructed in sectional lengths b^1. The lower part of the bag A is divided into two parts a^3, a^3, Fig. 4, and the lower end which projects from the casing B is surrounded by a rope-net a^5. Reef points are provided so that the bag may be shortened to fit a shorter casing. Apertures a^6 are provided for the admission or discharge of water, and pipes a^7 and a^8, Fig. 6, for the admission and escape respectively of air. An exterior buoyancy chamber C

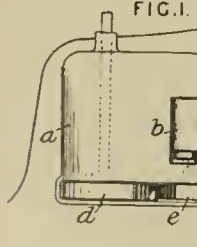


is provided, and an interior buoyancy chamber D is located between the top of the air bag and the interior of the casing. The lower part of the casing B is inwardly tapered and slightly flared outwardly round the lower edge. Exterior lifting-cables E, Fig. 6, are attached to flat wire strips *e* which bear on a wooden fender e^2 secured to the dome of the casing B. The exterior cables E and the interior cables a^2 pass respectively through exterior and interior cleats e^5 and e^4 forming part of a bracket e^6, and are connected together at their ends to form loops adapted to engage eye-plates F attached to the wreck. A fender H and guard-booms I are disposed as shown in sectional plan, in Fig. 10, and an internal strut *h* and bracing-rods *i*, *i*, Fig. 7, connect the guard-booms and lie between the two parts of the air-bag. Fig. 11 shows a shorter form of pontoon in which the exterior buoyancy chamber and the guard-booms are omitted.

No. 175,233. Propelling and Steering Ships, &c.

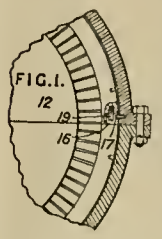
Flettner, A., 33, *Friedrichsruherstrasse, Grunewald, Berlin. March* 19, 1921, *No.* 8585. *Convention date, February* 10. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 4, 110 (iii). *and* 114.]

In apparatus comprising positively actuated auxiliary surfaces which actuate by a current of air or water a main surface such as steering or supporting planes of ships or aerial craft, or blades of propellers, windmills, or the like, the auxiliary surfaces and the main surface are coupled by gearing or the like so as to have co-ordinated movements. A main rudder *a* carries two auxiliary surfaces *b*, *c* and also connecting gear. Coaxial with, but free on, the main rudder is a quadrant *d* which gears with a quadrant *e* whose spindle is coaxial with, but free on, the second surface *b* and has a second quadrant *g* gearing with a pinion *h* fixed on the spindle of the second surface. By turning the quadrant *d* through a definite angle, the second surface *c* is first moved, and the action of the current thereon, together with the gearing, results in the main and auxiliary rudders taking up any desired position.



No. 175,488. Turbines.

British Thomson-Houston Company Limited, 83, *Cannon Street, London.—(General Electric Company, Schenectady, New York, U.S.A.) December* 20, 1920, *No.* 35713. [*Class* 110 (iii).]

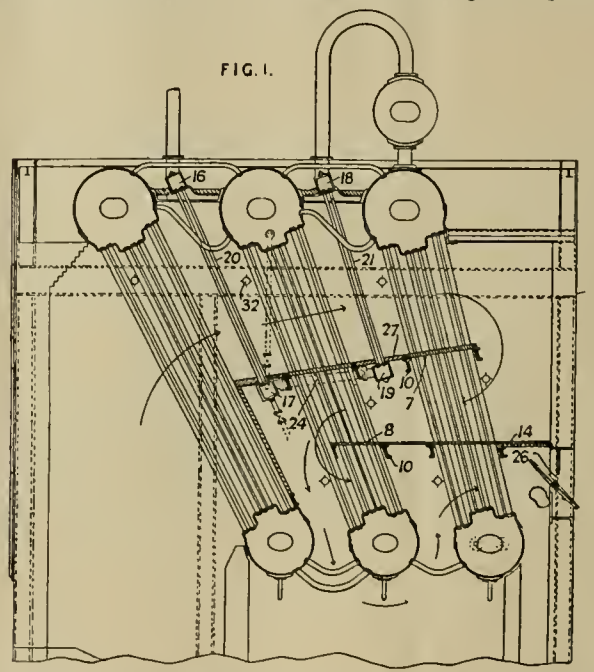


Casings.—The upper half 12 of the turbine diaphragm is held in place in the upper half of the casing during assembling by semicircular keys 17, inserted in the inner face of the casing, which project into recesses 16 in the diaphragm. When the turbine is assembled, the keys 17 are not in contact with the diaphragm. Pins 19, screwed into the pockets 16, keep the keys 17 from falling out, and cannot themselves work out owing to their length.

No. 175,765. Steam Generators.

Boden, A. P., 41, *Queen's Gardens, Ealing, London, and Healy, H. W.*, 13, *Shackleton Road, Hounslow, Middlesex. November* 24, 1920, *Nos.* 33191/20 *and* 3178/21. [*Classes* 51 (i) *and* 123 (ii).]

Water-tube boilers.—Boilers having upper and lower drums connected by banks of tubes are fitted with horizontal baffles which direct the gases first across the upper parts of the tubes and beneath the top drums, and then backwards and forwards across the lower parts of the tubes. The baffles 7, 8 are so arranged that the cross-section of the passes for the furnace gases gradually decreases in area towards the outlet 26. Each baffle is built up of longitudinal



and transverse cast-iron plates, placed between the tubes, and of tiles 27 placed between the tube-banks. The plates and tiles may be supported by transverse beams 10, by rings shrunk on the tubes, or by semicircular pieces secured against the tubes by wedges. The small spaces around the tubes are filled in, and the surface of the baffle coated with asbestos fireclay and cement. Soot dislodged by means of blowing nozzles 32 is removed through a slotted sliding door 14 at the back of the baffle 8. The steam is superheated in straight tubes 20, 21 connected to headers 16, 17, 18, 19 and placed between the boiler tube-banks. The bottom headers of the superheater are connected together by external tubes 24.

OFFICIAL NOTICES.

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15	,,	...	17′ 0″ × 5′ 0″ × ⅜″ ,,
25	,,	...	30′ 0″ × 4′ 6″ × ⅜″ ,,
120	,,	...	38′ 0″ × 7′ 0″ × ½″ ,,
44	,,	...	32′ 3″ × 6′ 6″ × ½″ ,,

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The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES — WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION — CARGO HANDLING APPLIANCES

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VOL. XLV. No. 537. JUNE, 1922.

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Mr. T. E. Thirlaway has been appointed Vice-chairman of Swan, Hunter & Wigham Richardson, Limited, Wallsend.

The death is announced of Mr. Charles Ernest Arnott. Mr. Arnott was a director of James Arnott & Sons Limited, oil merchants and refiners, Newcastle and Cardiff.

Captain M. Butterwick has been appointed marine superintendent of the Union-Castle Line in succession to Sir Benjamin Chave. Captain Butterwick has been in command of the *Dunluce Castle* for the past nine years.

Sir Archibald J. C. Ross, a director of R. & W. Hawthorn, Leslie & Co. Limited, St. Peter's Works, Newcastle-on-Tyne, has been elected President of the North-East Coast Institution of Engineers and Shipbuilders for the ensuing year.

Mr. Frederick John Moseley, Marine Superintendent of the Union-Castle Mail Steamship Company Limited, Southampton, who died in February last at the age of 58 years, left estate of the gross value of £2,780, the net personalty being £1,703.

Messrs. Ir. H. C. J. H. Banduin, engineer, and Ir. L. P. J. Smulders, adjunct-engineer, with the Dutch State Coal mines in Limburg, have been appointed, respectively, working-engineer and engineer with Werf Gusto, Schiedam, firma A. F. Smulders.

The death has occurred at Barrow of Mr. C. G. Roberton, O.B.E., manager of the submarine department of Vickers Limited. He was born in Glasgow where he started his engineering career, and went to Barrow 30 years ago. He was an expert on internal combustion engines, and had much to do with their development.

Mr. John George Kinghorn, of Ardoch, Prenton Hill, Birkenhead, and of Water Street, Liverpool, Consulting Engineer and Naval Architect, senior partner in the Metallic Valve Company, and late of the firm of Kinghorn Bros., who died in February last, left estate of the gross value of £68,900, the net personality being £64,959.

Commander William B. Wilkinson, R.A.N., has been appointed acting marine superintendent in Australia for the Commonwealth Government line of steamers. Commander Wilkinson was for many years in command of several of the Currie liners trading between Australia and the East, and has recently been engaged on naval survey work in Western Australia for the Australian Naval Board.

Mr. William H. Todd, president of the Todd Shipyards Corporation, New York, which claims to be the world's largest ship-repairing organisation, has been in England on a business trip. The Todd Shipyards Corporation has plants on both coasts of the United States. Robins Dry Dock & Repair Company, the Tebo Yacht Basin Company and the Clinton Dry Docks Inc., of Brooklyn; the Tietjen & Lang Dry Dock Company, Hoboken; the Todd Dry Dock & Construction Corporation, Tacoma; the Todd Dry Docks Inc., Seattle; the Todd Shipbuilding & Dry Dock Company, Mobile; and the White Fuel Oil Engineering Corporation, all operate under the direction of Mr. Todd, who founded the business and built it up to its present magnitude.

The death occurred suddenly, on May 4, of Mr. Alexander Cleghorn, M.Inst.C.E., F.R.S.E., M.I.N.A., at his residence in Hatfield Drive, Glasgow. During the last 15 years of his professional life Mr. Cleghorn was engineering manager of the Fairfield Shipbuilding & Engineering Company Limited, and he was one of the best-known marine engineers, not only on the Clyde, but also in the country. In 1905 he went to Fairfield and in 1920 he retired from active professional duties. He, however, maintained a keen interest in marine engineering affairs, and on the day before his death he completed a valuable contribution on an engineering problem to the Proceedings of the Institution of Engineers and Shipbuilders in Scotland, of which he was a Past-President. Mr. Cleghorn, who was a native of Fifeshire, was educated at St. Andrews University, where he won the Tullis gold medal for mathematics and natural philosophy. He then went to Edinburgh University where he obtained honours in mathematics and chemistry, and was a medallist in advanced dynamics and engineering. He also studied for a time at Glasgow University and there he was first and third prizeman in naval architecture. On completing his university career he became an apprentice with the firm of Robert Napier & Sons, Govan, a concern which had then attained a world-wide fame, and in their employment he became successively leading draughtsman, works manager and assistant manager, and he also represented the firm in Russia in connection with naval contracts for that country. From 1897 to 1905, Mr. Cleghorn was engineering manager for Barclay, Curle & Co., and, as already stated, he joined the Fairfield Company in the latter year as engineering manager, with responsibility for all engineering construction. During that period the firm constructed many notable vessels, the machinery for which was made under Mr. Cleghorn's supervision. In addition to being engineering manager, Mr. Cleghorn was also a director of the company. In 1917 he was elected President of the Institution of Engineers and Shipbuilders in Scotland, a post which he held for two sessions.

EDITORIAL.

THE OPERATION OF MOTOR TONNAGE.

While much has undoubtedly been written lately about the development of the Diesel engine, it must be confessed that the lion's share of such has been devoted to the scientific and manufacturing sides of the Diesel engine proper, and that reliable data relating to performance and operation has hitherto been somewhat difficult to obtain. Several factors have naturally contributed towards this scarcity of information. The sea-going engineer, from the very nature of his vocation, has seldom the time amid his other strenuous duties to prepare the necessary data, and the presence of a technical representative of the builders is not always possible. The author of a paper, "Actual running Costs of Motor Ships," recently read before the North East Coast Institution of Engineers and Shipbuilders, has been more fortunate than either of the foregoing. Mr. Madsen, as the representative of the Transatlantic Steamship Company, of Gothenburg, has been able to observe the performance of one of the company's new motor vessels, the *Yngaren*, on an extended maiden voyage, and is to be congratulated in having submitted some interesting comparisons of performance as between different types of motor vessel and between the *Yngaren* and a similar steamer. The owners also have, by the release of this data, set an example which might with advantage be followed by others similarly placed.

Elsewhere in this issue will be found an abstract of Mr. Madsen's paper already referred to. The author at the outset discussed the question of the initial cost of motor ships, but wisely refrained from probing very deeply into a subject which is manifestly complex and fluctuating. Few are likely to dispute the fact that a motor vessel to-day is more costly than a steamer, in other respects similar, or that the conversion of a laid-up steamer to a motor vessel may, unless strict attention is paid to detail, prove to be more expensive than the straight new motor vessel. Whether the engineers are responsible for the destruction of the "poetry of seafaring life," as stated by a friend of the author, is an open question, and it is no part of our intention to revive the "deck *versus* engine-room" controversy. The ship must have a master as in the days of sail, but the shipowner realises increasingly that "down below is the place where money is heavily consumed." For the economical operation of motor ships it is important that the engineers should be so remunerated as to encourage them to assume responsibility and to feel that they are appreciated, and particularly does this apply to the chief engineer. A steam engine may continue to function satisfactorily with average care, but an internal combustion marine engine calls for constant attention to detail, and the personal element in the latter plays a great part in operating results.

Certain disadvantages are associated with the use of a cheap fuel in a Diesel engine, and in his natural desire to keep down his fuel bill to the minimum the shipowner may pardonably overlook such questions as burnt fuel valves, scored cylinders, additional tank heating and settling considerations, &c. It would appear to have been the author's experience to have purchased fuel, nominally a Diesel oil, but to have been supplied with an oil containing excess proportions of sulphur and asphalt, and being, in fact, in all physical and chemical respects a crude boiler-fuel oil. In the fuel-oil market, as in any other market, there is always the possibility of having to pay for goods of a quality better than that actually delivered, and while the control of the market may not always be administered with the highest degree of equity, we cannot altogether conceive the average shipowner as the impotent victim of mighty oil trusts.

In the paper under discussion some interesting figures have been submitted on the twin-screw vessels of the *Bullaren* type, developing 4,000 i.h.p., and to average a speed of 13·72 knots over an observed distance of 9,314 miles on a fuel consumption of 143 grammes per i.h.p./hour is a fine performance for a cargo liner. A comparison has been drawn between the *Yngaren* and the *Auten*, two vessels with similar hulls, the first driven by a Doxford-Diesel engine and the latter a steamer. The *Auten* is a combined coal and oil-burner, and her daily consumption is given as 9·5 tons oil and 30 tons coal. It is stated that the 9·5 tons oil, if consumed in the *Yngaren* engine, would develop a greater s.h.p. than that obtained by the combined oil and coal in the *Auten* —resulting in a saving of 30 tons coal per day. These are striking figures, and when allowance is made for the 1,400 tons coal carried by the *Auten* over and above the 322 tons fuel oil, with the attendant loss of carrying capacity, the case for the motor vessel is very strong. On the question of engine-room personnel the figures are also strongly in favour of the motor ship. In the *Yngaren* the total operating personnel is 13, while in the *Auten* the number is 18. The corresponding figure for the larger twin-screw Diesel vessels of the *Bullaren* type is 16 men, *i.e.*, actually less than the number necessary on the smaller-powered single-screw steamer.

There is much in Mr. Madsen's paper of a practical nature, which will amply justify its close perusal by the shipowner and his technical advisers. To those who are interested in the commercial success of the motor vessel it cannot be other than helpful to read papers such as these, and we should like to express the hope that other owners should, wherever possible, similarly release practical operating data.

THE MATHEMATICS OF SHIP DESIGN.

In the current issue of the *Nineteenth Century* there is an interesting article on "The Romance of Mathematics," in which the writer gives the following somewhat unfortunate illustration: "He (Lord Kelvin) made it possible to design the Dreadnought type of battleship by working on the mathematical conditions of stability of floating bodies." It is open to question whether the stability or otherwise of the Dreadnought was due to Lord Kelvin alone, but the fact remains that the theory as it stands is one of the most remarkable examples of the successful application of pure mathematics to problems of intense practical importance. In modern shipbuilding more, perhaps, than in any branch of engineering, mathematics is almost indispensable, and this fact is reflected year by year in the transactions of the Institution of Naval Architects and other similar institutions. There has been much criticism recently of the somewhat theoretical nature of the proceedings of these societies. The critics deplore the fact that the papers read involve so much mathematics. "You cannot design a ship by mathematics" is a remark not infrequently heard. At the same time it is equally obvious that one cannot design a successful ship without mathematics, although the application of the mathematics may be "secondhand" rather than direct, as in the use of Lloyd's rules.

In the mental equipment of the naval architect a knowledge of the theory of the stability of floating bodies is probably the most frequently called into play. It is a primary condition of design that the proposed vessel should have ample stability in all normal and even abnormal conditions. No designer, however much he may despise the use of x and y, can afford to neglect the powerful aid of the various formulæ and methods of calculation which have been developed. The rolling of ships is a closely allied subject, and is even more susceptible to mathematical treatment. Much of the comfort and freedom from excessive rolling of our large passenger liners is directly due to the fact that the designer is

able to calculate and adjust at will the period of roll. In battleship design this is of even greater importance, since a steady gun platform is essential.

Resistance and propulsion do not necessarily involve mathematics of the same high order, but in the analysis and application of model results to full-sized vessels the designer learns to appreciate the value of the mathematical and experimental work of the Froudes, Admiral D. W. Taylor, Mr. G. S. Baker and many others. One might mention here the importance in design of the determination of a suitable propeller, which can only be done satisfactorily by calculation in conjunction with experimental results in each individual case.

Strength of ships is a branch of the science of naval architecture which is unhappily somewhat throttled by the standard scantlings determined by the registration societies. In vessels of unique design or abnormal proportions, however, strength calculations must frequently be made, and even for normal types the registration societies are always prepared to consider new departures in construction, provided a sound scientific basis can be adduced. It is questionable, however, whether the ancient standardisation is in the best interests of the industry. Government regulations on freeboard, tonnage measurement and watertight subdivision are unsatisfactory in a similar way, the tendency being to degrade the science of naval architecture into a form of " wangling " or " science of the evasion of regulations."

In this brief review of the application of mathematics to shipbuilding, mention must also be made of launching and vibrations. In the transference of a large 50,000-ton liner from the stocks to the water some form of launching calculation is essential in order that a safe and steady launch may be ensured. The determination of the longitudinal position of the vessel's centre of gravity is a tedious but inevitable necessity in this calculation. An estimate of the natural period of vibration of a proposed ship is another calculation which it is sometimes necessary to make. If this natural period synchronises with the period of vibration of the machinery abnormal amplitudes may result. Where heavy reciprocating machinery is employed it is advisable to calculate the vessel's free period beforehand in order that synchronism may be avoided.

TURBINE REDUCTION GEARING FOR MERCHANT SHIPS.

In the period immediately following the war the scarcity of tonnage created a very considerable demand for new merchant ships, and in the selection of the propelling machinery for this new tonnage, the individual shipowner was faced with several considerations. The war period had witnessed a rapid development in the application of double-reduction gearing to merchant ships—particularly American—and, given a reasonable degree of efficiency, undoubted economies were possible with this method of propulsion. Progress had also been made with the internal combustion engine, and the results achieved by both these forms of propulsion were such as to cause the shipowner to pause before deciding upon steam reciprocating machinery which, however reliable, might conceivably become rapidly obsolete. To many shipowners the adoption of the oil engine and the almost complete elimination of steam on board, appeared to be—we speak of three years ago—so drastic as to be comparable only with the policy known among the seafaring fraternity as " burning their boats." The fine heritage of steam, and the excellent services rendered in times past, not unnaturally tended to result in the double-reduction geared turbine finding greater favour than the internal combustion engine, especially as considerable experience had already been gained with the direct-drive turbine. In a paper " Some Remarks on Turbine Gearing " recently read before the Liverpool Engineering Society, Mr. Sterry B. Freeman, C.B.E., dealt with the several factors confronting the shipowner in the choice of propelling machinery, and reviewed the practical results so far obtained by reduction-gearing on service.

Sufficient data has not so far been accumulated to enable us to arrive accurately at an estimate of the relative first costs of steam reciprocating, double-reduction turbine and Diesel machinery, but it is claimed that the last is at least 30 per cent. above the cost of the first. The value of weight and space saved in any given vessel is largely dependent upon the nature of the service upon which the ship is engaged. On the question of actual fuel consumption, the Diesel engine takes first, and the steam reciprocating engine last place, but when the relatively high cost of fuel oil is taken into consideration, and having regard to the fine performances registerd by superheated steam turbine reduction-geared installations, the annual balance-sheet will generally show only a very slight advantage for the internal combustion engine. It is pointed out that the reliability of the turbine *per se* is now thoroughly established, and that what is wanted is a sound, double-reduction gearing which will at once merit the confidence of the shipowner.

During the present year much has been written on the question of the reliability of double-reduction marine gearing and the comparative immunity from failure of the single-reduction gears in Naval service has been carefully analysed for the possibility of some solution of the double-reduction problems being found. The high tooth pressures adopted in double-reduction gears has been thought in several quarters to be responsible in some measure for the unsatisfactory performance of these gears, and experience has led to the adoption of a more conservative policy resulting in tooth pressures more nearly approaching those obtaining in single-reduction practice. Mr. J. Wilkie and Dr. Smith in their papers recently read before the Institution of Naval Architects, put forward the view that the one specific cure was to be found in the adoption of the nodal drive. The bulk of practical experience cannot be said to support this contention, and while there is no reason to doubt the merits of the nodal drive in the *Melmore Head*, the fact nevertheless stands that several double-reduction gears are giving satisfactory service to-day which have not been arranged on the nodal system. Among engineers the general belief exists that irregularities in the teeth are primarily responsible for the noise and vibration in these gears, and that the obvious remedy is the employment of methods of greater precision in cutting. There would also appear to be some scope for increased attention being given to the material used in these gears, and steel makers are now fully alive to the nature of the requirements to be met.

That the problems attending the design and construction of these gears are complex cannot be gainsaid. This is amply demonstrated by the fact that difficulties have been experienced on some half-dozen new high-powered ships recently built in this country. The builders enjoy a world-wide reputation for high grade workmanship and material, and are fully alive to the issues involved. The qualities of craftmanship and skill which built up these reputations, will, we fully believe, prove themselves superior to the present difficulties associated with marine-reduction gearing. Such are the economic advantages offered by the double-reduction gears that we cannot afford to abandon this method of marine propulsion. Moreover, the experience gained up to the present can be spread over a comparatively short period, and the vast advances made in marine propulsion subsequent to the introduction of the steam turbine—which has not been itself altogether immune from accidents—seem to warrant the exercise of patience and renewed effort towards the discovery of a final solution of those troubles to which double-reduction gears are heir.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Theorie des Schiffes. By Prof. H. Herner. Leipzig: Verlag Max Jänecke, Hospitalstr. 10. 338 pp. 202 ff. 8¼ in. × 5¾ in. × ¾ in. Price (in Germany) 94·6 marks.

Prof. Herner's work on "Theoretical Naval Architecture" may be considered as the standard German elementary text-book on the subject. First published in 1908, it has now reached its third edition, and several important amplifications have been introduced therein. The book is divided into seven main sections as follows: Introduction, Displacement and Trim, Form Coefficient, Stability, Rolling, Resistance and Propulsion, and finally, Strength. The first four sections are treated very fully and occupy 268 pages. The treatment is distinctly good, and the subjects are dealt with in a manner very suitable for designing and routine technical work. Throughout these sections great emphasis has been placed upon purely graphical means of calculation, and many such methods are given. These graphical methods are one of the best features of the book, and the author is to be congratulated on his endeavour to make these simple and labour-saving devices better known to the shipbuilding profession.

With regard to the remaining sections, these do not seem to have been brought up to date. This is especially so in the section dealing with resistance and propulsion. In this section it might reasonably have been expected that some of the recent work of Schaffran and Gebers on ship resistance and propeller design might have been incorporated. Similarly, the section on strength of ships is somewhat meagre and could well be amplified without exceeding the bounds of what may be called pure naval architecture and trespassing on the province of structural design. On the whole the book is quite good, and the nature and standpoint of the treatment, being quite different from that of the usual English and French, enables one safely to recommend the work to the student and to the practising naval architect.

Liquid Fuel and Its Apparatus. By Wm. H. Booth, F.C.S. London: Constable & Co. Limited, 10, Orange Street, Leicester Square, W.C. 8½ in. × 5½ in. × 1 in. 308 pages. Price 10s. Numerous illustrations.

In this work the author traces the historical and geological features associated with the production of petroleum and the hydro-carbons. The physical and chemical properties of a great variety of liquid fuels are described in simple language not unduly burdened with technicalities. The book has as its object the presentation in a convenient form of the more immediate practical points of the author's larger work on the subject as far back as 1902. In the section dealing with the practical application of liquid fuel, it is felt that greater advantage could have been taken of the recent far-reaching developments in the use of liquid fuel in marine boilers and in Diesel engines—the section on oil engines is dismissed in eight pages. Fuel prices have been quoted, and inasmuch as these would appear to have reference to the stable exchange period of 1902—the franc is given as the equivalent of 10d., and the dollar as 48d.—such should be viewed in a comparative and not in an absolute basis. A series of useful tables is submitted; the book is well illustrated and contains a 10-page index.

Seaton and Rounthwaite's Marine Engineering Pocket-Book. By A. E. Seaton and H. M. Rounthwaite. London: Charles Griffin & Co. Limited, Exeter Street, Strand, W.C. 2. 6½ in. × 4¼ in. × 1½ in. 770 pp. Price 15s.

This manual requires no introduction to our readers, many of whom will recall its advent some 30 years ago. In this, the fifteenth edition, a considerable amount of amendment and addition has been undertaken which have rendered the pocket-book of correspondingly enhanced value. Many of the old rules of the classification societies have been superseded by unified rules, based on the recommendations of the British Marine Engineering Design and Construction Committee and now adopted by these societies. Many additions have been made to the text embodying every phase of modern development, including the double-reduction geared turbine and the Diesel engine. A note of regret is sounded that, in the development of the latter, we in this country should have been, to a great extent, content to manufacture these engines to patents and designs of foreign origin. The library of every shipowner and his technical advisers, and all associated with marine engineering, cannot be considered complete without a copy of this book.

Boiler Plant Testing. By David Brownlie, B.Sc. (Honours in Chemistry). London: Chapman & Hall Limited, 11, Henrietta Street, W.C. 2. 5¾ in. × 8⅝ in. × 1 in. 168 + xi pages. Price 10s. 6d. net.

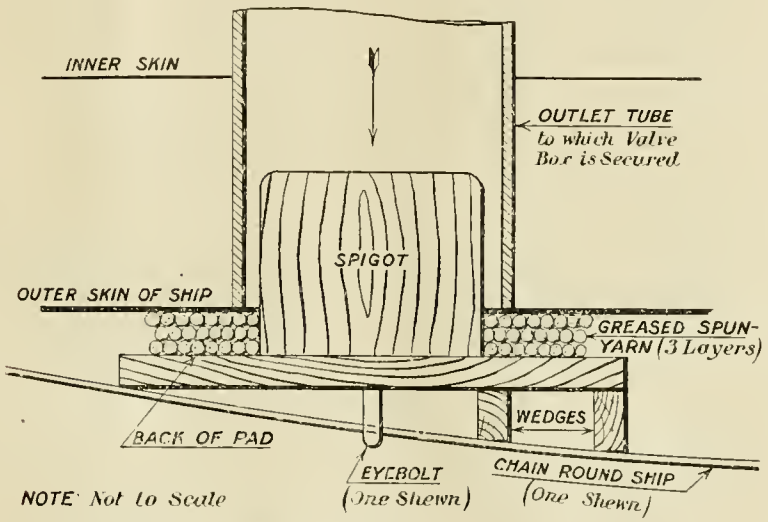
The vital part which fuel economy plays in the successful operation of shore or marine boiler plants is now being given something more nearly approaching the consideration which it merits and this is no doubt due to the present-day high fuel costs. In this work the author reviews the existing methods of boiler-plant testing and directs a very spirited criticism at the standard code in Great Britain, which is that of the Institution of Civil Engineers. It is pointed out that the present code is palpably out of date, and the suggestion is made that the task of framing a new code is more properly the joint concern of the Institution of Mechanical Engineers and the Institute of Chemical Engineers. It cannot be gainsaid that since the standard code was last revised in 1913, great advances have been made in arriving at methods of fine precision in the measuring of steam, water and CO_2. At the recent spring meetings of the Institution of Naval Architects, it was agreed that the time was ripe for a complete revision of the standard code, and Captain H. Riall Sankey undertook to bring the matter before a meeting of the Institutions of Civil and Mechanical Engineers and Naval Architects. Mr. Brownlie suggests that a standard international boiler testing code should be jointly drawn up by the engineering and scientific societies of Britain, America and France. The statement is made that we are far behind our American contemporaries on the question of practical boiler testing, and suggested report sheets are outlined in accordance with the proposed international code. It is felt that the author has been somewhat categorical in his treatment of the "Civils," and while their standard code is decidedly inadequate for present-day practice, they are not wholly, but merely jointly, responsible for the existence of a code now one decade obsolete. We commend the work to all interested in a subject which has not enjoyed the attention it merits.

TRADE PUBLICATIONS.

Motor Starters.—An advance copy of a well-illustrated booklet has recently been received from the General Electric Co., Kingsway, W.C. 2, describing their latest types of motor starters and starting panels. Fully dimensioned line drawings and outline diagrams are included, also full particulars and prices of direct-current face plate starters of the open, semi-enclosed, totally enclosed cover and totally enclosed types, plain A.C. starters, oil-immersed motor starters, &c.

EXAMINATION OF UNDERWATER FITTINGS WITHOUT DRYDOCKING.

Before a certain steamer was undocked the underwater fittings were thoroughly examined, overhauled and refitted; and all underwater valves were closed. After the vessel was floated instructions were given for the main inlet and discharge valves to be opened in order to flood the condenser. The discharge valve jammed half open. Divers were sent down but could discover nothing wrong. It had been considered that if the main circulator were started up, the flow of water might dislodge the obstruction. As no steam was available the steam valve chest cover was removed from the circulating engine, and air supply from the shipyard was introduced by means of an adaptor. In this way an air pressure of 80 lbs. per sq. in. was obtained at the engine, and this pressure was found sufficient to run the circulator. This method, however, proved unsuccessful, and the discharge valve remained jammed half open. As the cost of redocking the ship was likely to prove a serious item, it was decided to make a plug pad to cover the outlet tube, as shown in the diagram. It was considered that the pressure of the water outside would keep the plug in place during the removal and examination of valve and box.



Method of Plugging Discharge Valve Orifice.

The discharge valve was of the ordinary flat shutter type, and the outlet orifice of tube connecting the inner and outer skins of the ship was 25 ins. diam. Unfortunately, the bilge keel was situated near the discharge orifice and it was not possible to pull the plug up hard to its seat. The plug was constructed as follows:—Two-inch planking was used for the outer cap, and to this a built-up wooden spigot was secured, the spigot being a very slack fit in the discharge tube. The length of spigot was 15 ins. Well-greased spun yarn was wound round the spigot at the base making three layers at the outer flange, as shown in sketch. Divers were then sent down to place the pad in position. The pad was provided with two eye-bolts, through which chains were passed and these chains were secured to the upper deck on either side, passing entirely round the ship's bottom. As the bilge-keel prevented the chains keeping an even pressure on the pad, wooden wedges were driven between the chains and the pad on the side on which the bilge keel projected. As no steam was available to work the fire and bilge pump, a connection was made and compressed air was supplied to the steam valve chest of this engine. It was necessary to use this pump in order to keep back any leak into the bilges, and also to keep the discharge tube clear of water when valve had been removed. In addition, a salvage steamer stood by the ship in case of emergency.

When all was ready the valve box cover was removed, and the valve and box examined. It was found that a wooden wedge had worked right into the valve box, turned end on, and so prevented the valve closing. It is considered that one of the dock shore wedges had become held up in the tube, and when the valve was partly opened, had worked its way in as described. The wedge was removed and valve box closed up, the whole operation after fitting the pad having taken less than 10 hours. By this method of repair re-docking was avoided and a saving of several hundred pounds was effected.

TRANSVERSE METACENTRIC HEIGHT.

To the Editor of
The Marine Engineer and Naval Architect.

Armstrong College,
Newcastle-on-Tyne,
May 17.

I was interested to read in your April issue a letter from Mr. G. H. Murray, in which he has been good enough to give the origin of the "straight line" formula which I happened to include in the first instalment of my article on the Transverse Metacentric Height of Ships. At the time I prepared the article I endeavoured to trace the origin of the formula, but failed because, as I now find, no transactions of the Aberdeen Mechanical Society are available in the principal technical libraries here in Newcastle.

A certain pleasurable interest is added to one's work when the origin and basis of one's methods are definitely established; and I am pleased, therefore, that you have been able to give a wide publicity to Mr. Murray's work in this branch of naval architecture.

E. V. Telfer.

BELLOWS EXPANSION PIECES.

To the Editor of
The Marine Engineer and Naval Architect.

May 5, 1922.

With reference to the article on the conversion of the *Mauretania* to oil burning in your April issue, we notice on page 136 you make reference to the use of "Bellows" expansion pieces in the liquid fuel piping of the *Mauretania* and state that "it is believed that this is the first instance of this type of expansion piece having been fitted for this purpose."

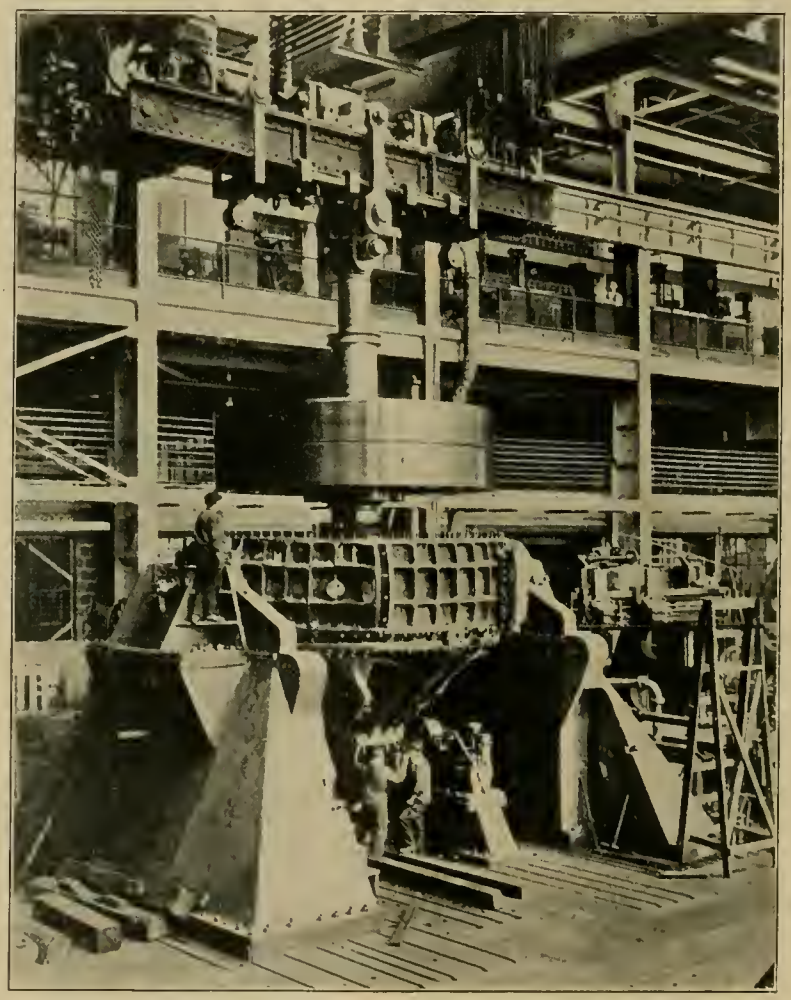
We beg to point out the fact, however, that the shipbuilders, Chantiers de St. Nazaire, adopted the "Bellows" expansion pieces in the Transatlantique liner *Paris*, of the Compagnie Générale Transatlantique, after having compared the results obtained from the tests they made on this device with the usual method of overcoming expansion by means of bends in the pipes, and we shall be glad if you will correct the statement accordingly.

For the Wallsend Slipway & Engineering Co. Limited,
A. Laing, *Director.*

THE LATEST SPERRY GYRO-STABILISER INSTALLATION.

New 120-Ton Stabiliser to be installed on American Passenger Liner "Hawkeye State"—General Principles—Some particulars of Rolling Experiments recently carried out on an Italian Destroyer.

From time to time a great variety of devices has been introduced for the prevention of rolling of ships at sea. Remarkable advances have been made in recent years in the matter of luxurious accommodation on board the largest liners, but it is significant that corresponding progress has not been made in eliminating the very obvious discomforts associated with the heavy rolling experienced in rough weather. That this is so, and that even the largest liners are not proof against the forces of the elements, was demonstrated some months ago when the *Olympic*, on a voyage from New York to Southampton, developed an alarming roll and had several ports stove in during a gale of unusual severity. These anti-rolling devices have assumed various forms. An arrangement of pendulum weights has been tried on a small scale, but owing to the space required and the difficulty of adapting this arrangement to vessels of large size, it has not found extended application. Several well-known liners have been fitted with a system of anti-rolling tanks, and while satisfactory results have in some cases been recorded, the adoption of this system has not been by any means general. The application of the principle of the gyroscope to the stabilising of ships bids fair to ensure a greater degree of comfort to passengers in all weathers than any device hitherto evolved. The gyroscope as a ship stabiliser has been perfected by Dr. Elmer A. Sperry, and several vessels have already been equipped with the Sperry Gyro-Stabiliser and have given very satisfactory performances.



"Hawkeye State" Gyro-Stabiliser—Gyroscope Flywheel being lowered in place at Philadelphia.

Among the vessels so equipped may be mentioned the yachts *Naomi*, *Guinivere* and *Lyndonia*, the *Guglielmo Pepe*, an Italian destroyer of 1,500 tons, and the American freighter *Huron*. In addition, there are under construction equipments for two train ferry-steamers for the Japanese Government, a 10,000-ton cruiser for the Japanese Imperial Navy, and a set for the 20,000 tons United States Shipping Board passenger liner *Hawkeye State*. On this and on page 221 we produce photographs showing the gyro-stabilizer for the last vessel. This represents the largest gyroscope so far constructed in the world, and it is also the first gyroscope to be installed on a passenger liner. A series of tests was recently carried out on this unit at the Philadelphia works of the Westinghouse Electric Manufacturing Company before a representative body of naval and merchant-service engineers. These tests are reported to have been of a highly satisfactory nature, and it is understood that this gyroscope will be installed on the vessel as soon as service conditions permit—probably during this month. The stabiliser weighs no less than 120 tons and is designed for a speed of 800 r.p.m. During the test, an overspeed of 10 per cent. was reached, *i.e.*, 880 r.p.m., and it is stated that such is the energy stored in the flywheel that it will revolve for a period of about 18 hours after the power is shut off.

On page 219 we produce a diagram illustrating the principle on which the main gyroscope functions. The action is controlled by a small gyroscope situate at a convenient point in the vessel. This control gyroscope registers the direction of the roll and automatically sets in motion the main gyroscope in the direction necessary to counteract the motion of the vessel. The stabiliser consists of a heavy wheel electrically driven and mounted in a cast-steel case which is provided with bearings and is fitted in the ship with the axis of these bearings in an athwartship plane. The spinning axis of the gyro-wheel is at right angles to these bearings. Should the case be moved in its bearings a powerful gyroscopic reaction is produced in the 'thwartship direction. The control gyro, on account of its great sensitiveness, responds to the slightest acceleration of the vessel in the thwartship direction and immediately an impulse is received from a wave, the control-gyro energises an electric motor, known as the precession motor. This motor turns, or precesses, the main gyro-case by means of the toothed quadrant shown in the left of the photograph on page 221. Precession of the main gyro-case produces a powerful gyroscopic reaction in the 'thwartship plane, which

tends to neutralise the rolling impulse caused by the wave. When this impulse has been destroyed, the control-gyro stops the precession motor and the apparatus is then in a position to deal with the next wave impulse.

We produce a series of rolling curves recorded from actual tests carried out on the Italian Navy Scout *Guglielmo Pepe* in the Gulf of Spezia from March 3 to 11 of this year. These curves are of considerable interest, and, with the amplitude of roll plotted against a time base the results are readily visible. In the top set of curves the vessel was stopped and was rolling under the influence of a light swell on the quarter. The remarkable roll-quenching effect when the Sperry gyro-stabiliser is brought into action is clearly shown. The two lower curves show a comparison between natural and forced dying-down rolling. In this case the vessel was in still water and rolling was developed by men, the mean period of roll being 9·6 seconds and the maximum amplitude 15 deg. Under natural conditions dying-down was not complete until 31 oscillations had taken place subsequent to the cessation of the rolling effort. With the gyro in action, quenching was complete within the period occupied by just over one oscillation.

Having regard to the enormous energy generated in a fly-wheel of this magnitude and revolving at such high speed, considerable discussion has naturally been raised as to whether the gyro-stabiliser does not impose excessive stresses on the structure of the ship. A sea wave approximates in form the trochoidal wave, with a height varying from $\frac{1}{16}$ to $\frac{1}{25}$ of its length. The maximum inclination of such waves is about 12 deg. but, as this inclination is limited in extent, the effective inclination—inasmuch as this more nearly determines the motion of the ship—should be considered, and this may reasonably be taken as about 3 deg. The rolling of a vessel is not the direct result of any individual wave, but is the cumulative result of a large number of relatively small impulses. Should the vessel be free to respond to these impulses a heavy roll will inevitably develop, but if each individual impulse is neutralised or quenched as it occurs, the configuration of the vessel will be practically unchanged. The forces brought to bear on a ship by the stabiliser are therefore only those sufficient to quench the roll increment for which the stabiliser may be designed.

Owing to the localised weight and the anti-rolling forces developed, specially reinforced foundations and heavier scantlings in the vicinity are naturally called for, but inasmuch as similarly-strengthened seatings are equally necessary for engines and reduction-gear casings, no undue difficulties should arise in this respect. The loss in deadweight-carrying capacity which might be argued as an objection to the fitting of a gyro-stabiliser, does not materially arise in a passenger ship, and will certainly be completely outweighed by the additional comfort afforded the passengers.

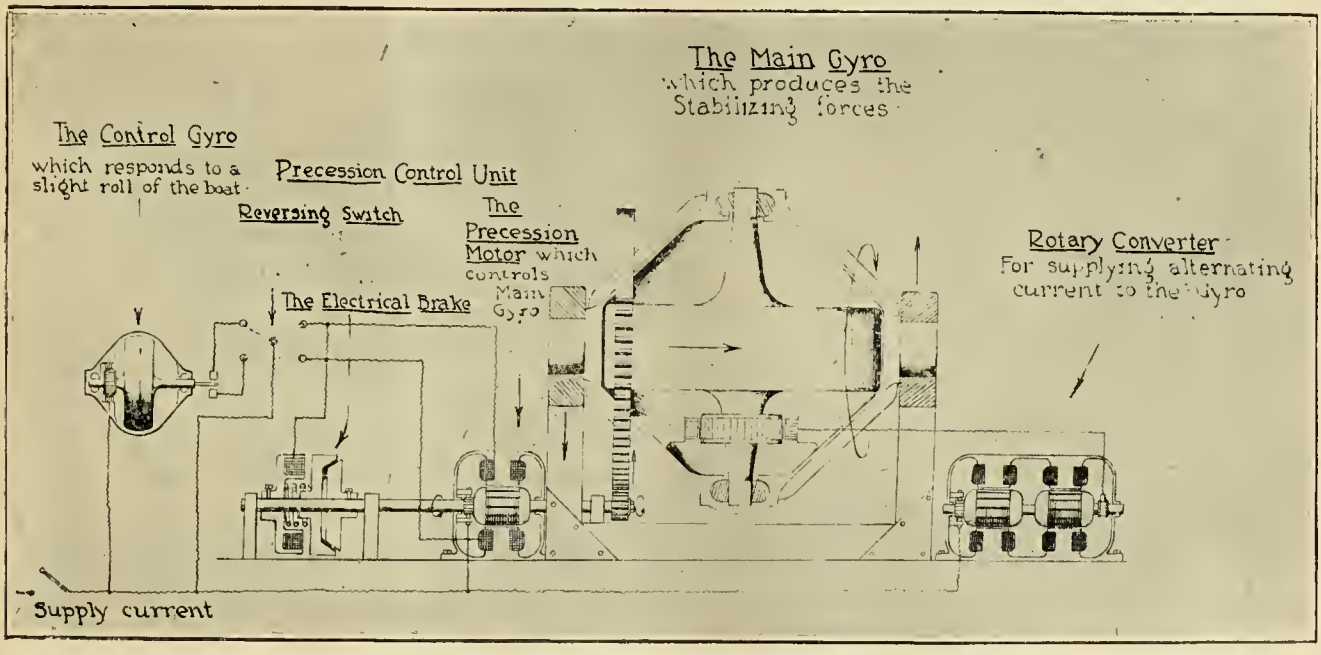

The Main Gyro
which produces the Stabilizing forces
The Control Gyro
which responds to a slight roll of the boat
Precession Control Unit
Reversing Switch
The Precession Motor which controls Main Gyro
The Electrical Brake
Rotary Converter
For supplying alternating current to the Gyro
Supply current

Diagram illustrating the Principle on which the Gyro-Stabiliser functions.

FLAT PRICE CONTRACTS FOR WORK PERFORMED AT THE PANAMA CANAL.

The Panama Canal authorities have adopted a policy of making flat price contracts for work performed by its departments and divisions, where practicable, in place of the former "cost plus" system. This practice applies both to work for the departments of the Government and to work for individuals and companies. "The practice of setting a price for a job and adhering to it," says the *Panama Canal Record*, the official organ, "was adopted for two principal reasons. One is that it should attain economy in the Canal organisation. It will throw directly on the organisation doing the work any loss from failure to perform efficiently, and hence increase the direct responsibility and active interest of all involved. The other is that for work performed for individuals and companies, especially steamship repairs and salvage work, it is frequently essential to quote an absolute and fixed price which will not be exceeded. In some cases the decision whether to have certain work performed rests on knowing accurately what it would cost, and in many others it avoids suspense and misunderstandings and irritation, to be able to make a definite contract."

Costs will be estimated and charged as before, and for any interest that desires work to be done for a flat rate, about 10 per cent. of the estimated cost is to be added to insure against loss. That is, it is supposed to insure against loss; but if it does not, the interest for which the work is being done will not bear the loss.

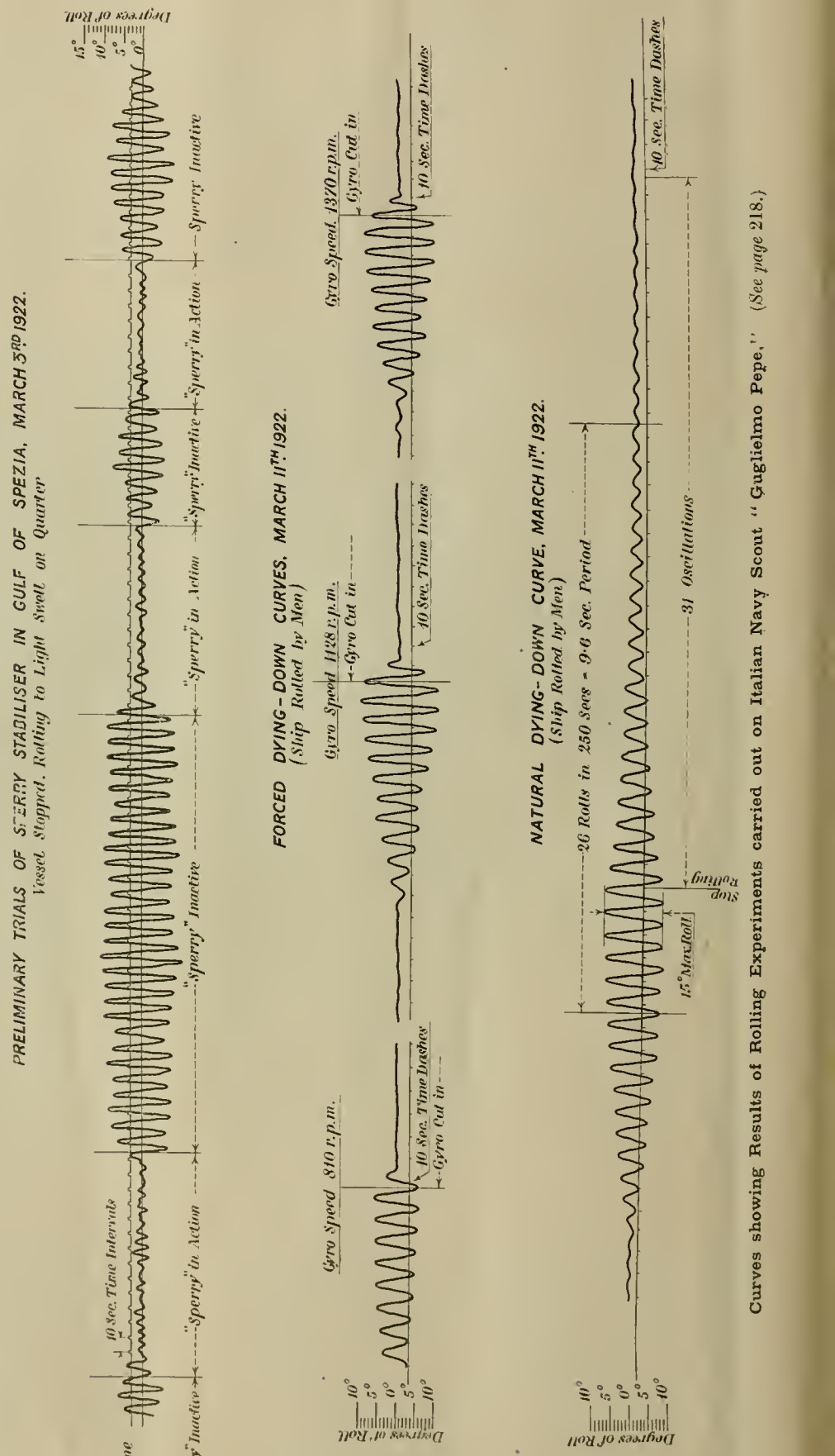
FOUNDRY PRACTICE.

Important Conference at Birmingham.

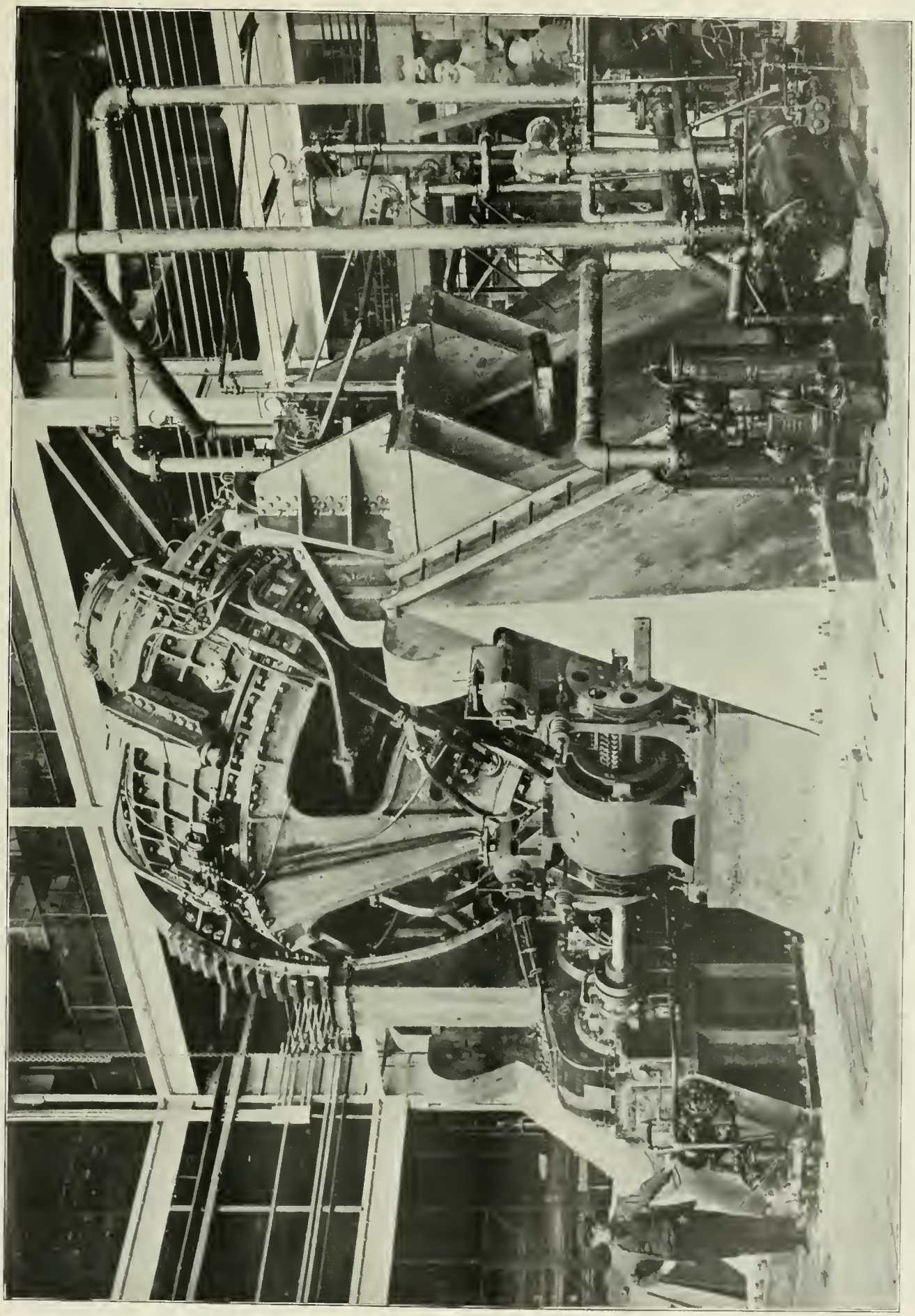
Arrangements are now complete for holding in Birmingham, on June 20 to 23, the most important gathering of technical men that has probably ever met in one week in the Midlands. Three large technical institutions will simultaneously hold their annual conferences to discuss papers of practical utility either to themselves or to industry at large. The Institution of Automobile Engineers will hold a session to discuss matters affecting the motor industry, and the Municipal Electrical Association holds a conference upon matters affecting their interests.

The principal conference is that of the Institution of British Foundrymen, when its members from all parts of the country will meet to discuss an exceptionally important programme of foundry papers. Although this Institution was founded in Birmingham in 1903, this is only its second visit to the district. It has now over 2,000 members, and the influence it now holds in the industrial world has enabled it recently to obtain its Royal Charter. Besides their technical sessions, various hospitable functions and visits to representative works have been arranged, and the Lord Mayor has invited the members to a garden party at the Botanical Gardens. To synchronise with the conference, a Foundry Trades Exhibition has been organised by the Institution and the Chamber of Commerce in the Bingley Hall, with Lord Weir as President. This is not only the first exhibition of its kind ever held in this country but in Europe, and it promises to be a very important function. The exhibition will be open for ten days, and the Duke of York will visit the exhibition during the week. The organisation of the Foundrymen's Conference, &c., is in the hands of Mr. Thos. Vickers, of the British Cast Iron Research Association.

DUBLIN SHIPYARD WAGES.—A conference between the employers and workers in the Dublin shipyards on a proposed reduction of wages resulted in an agreement to make no change owing to the abnormal conditions now prevailing. Afterwards, at a meeting of the workers, it was decided to approach the Government to put forward a claim for consideration in any work they put in hand with a view to giving employment in the local shipyards. Complaint was made on the small encouragement given to shipbuilding in the port.

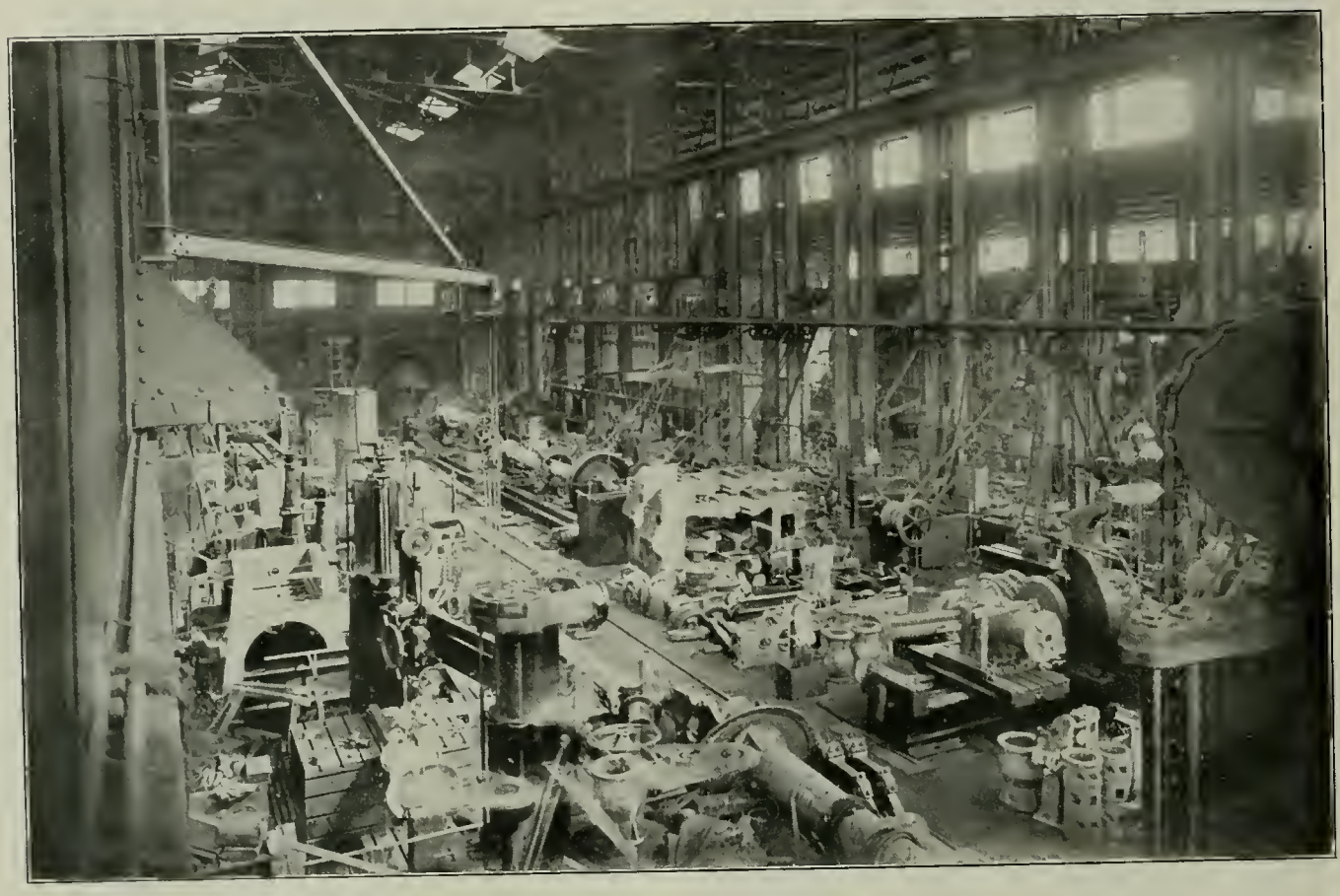


Curves showing Results of Rolling Experiments carried out on Italian Navy Scout "Guglielmo Pepe." (See page 218.)

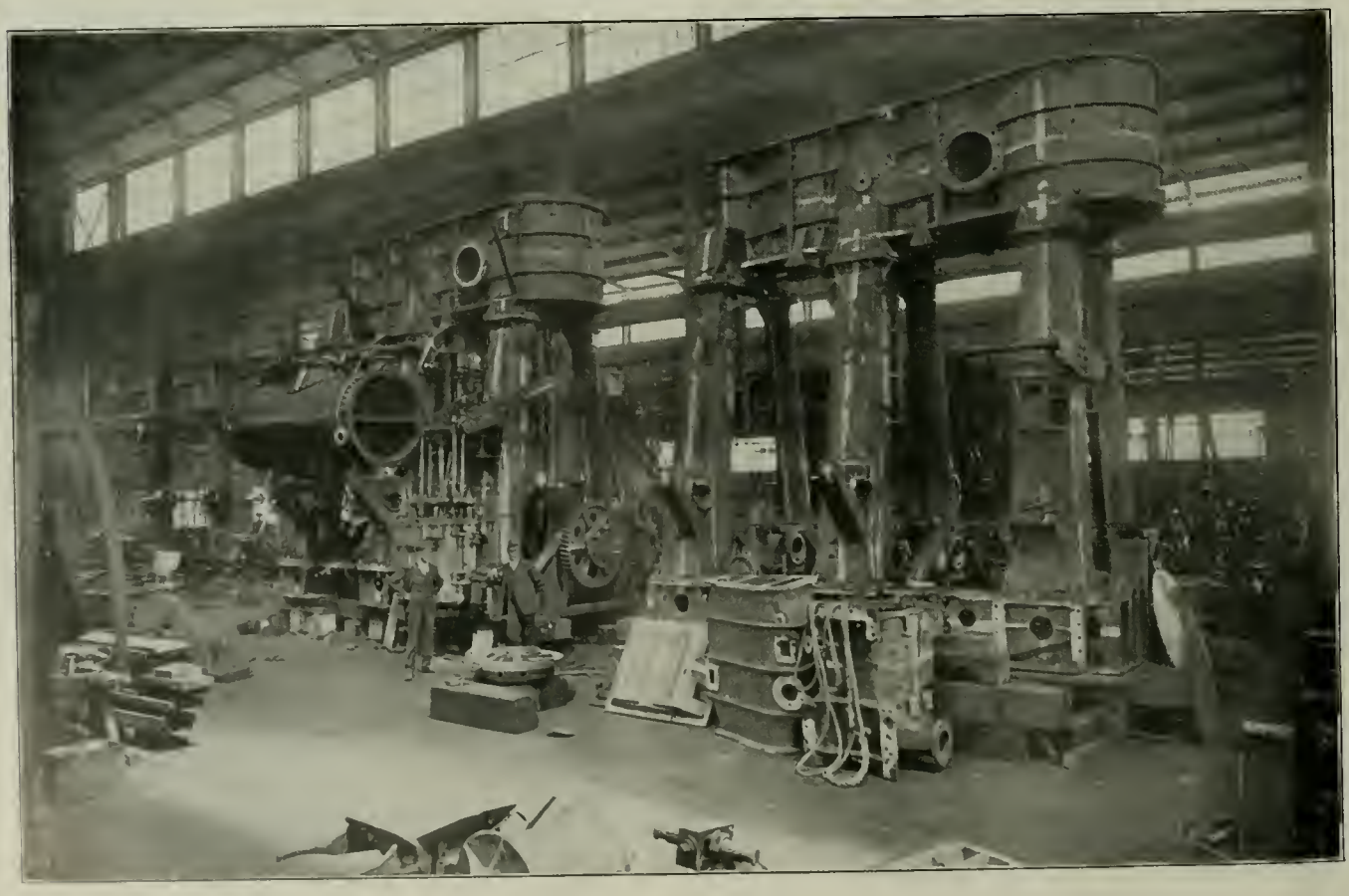


Sperry Gyro-Stabiliser for "Hawkeye State."—View showing Stabiliser in Precessional Position at the Westinghouse Works, Philadelphia.

COMMONWEALTH GOVERNMENT ENGINE SHOPS.



Section of Machine Shop.



Section of Fitting Shop, showing Triple Expansion Engines for Vessels of 3,360 gross tons.

COMMONWEALTH GOVERNMENT ENGINE SHOPS. (*See page* 247.)

General View of Main Foundry.

Main Foundry, with Pipe Casting Platform in Distance.

COMMONWEALTH GOVERNMENT ENGINE SHOPS. (*See page* 247.)

General View of Brass Foundry.

Central Bay of Boiler Shop, showing Sections of Water-Tube Boilers.

DEVELOPMENTS IN THE DESIGN OF MARINE OIL ENGINES.—III.

Construction of Reciprocating Parts—Starting and Inlet Valve Arrangements—High-pressure Solid-injection Fuel Pumps—Air Compressors.

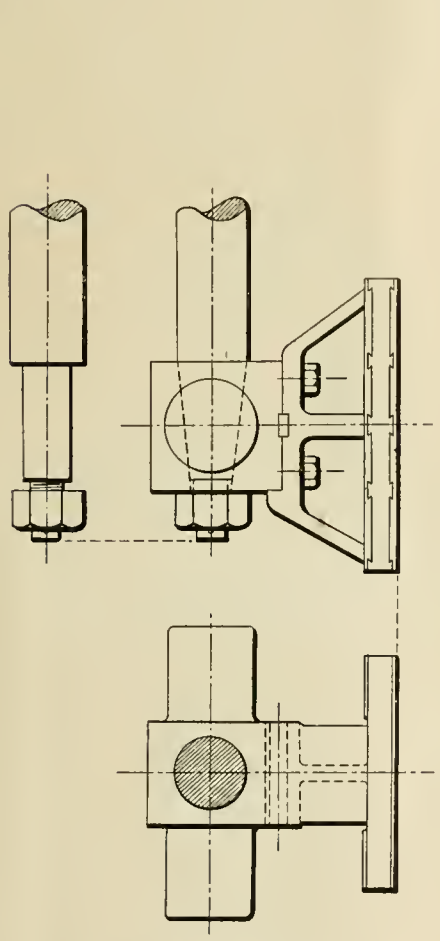
To proceed further with the development of the design of the Diesel engine, the principal outstanding mechanism in point of size remaining to be dealt with is the connection from the piston to the crankshaft, which in the case of a trunk-piston engine is made direct from the piston through a gudgeon pin and connecting rod direct to the crankshaft, all the side loads due to angularity of connecting rod and other side stresses being taken on the cylinder liner through the extended walls of the piston. In the more usual marine crosshead type of engine the piston is connected through a piston rod to a crosshead, the latter being guided to take all ahead and astern loads, thus making it possible considerably to shorten the piston, and thence to the crankshaft by the usual connecting rod.

The piston rod is invariably of circular section, of wrought steel, and is bolted at the top by a flange to the underside of the piston by means of studs of ample proportion to take the inertia loads and the friction due to the piston rings. The method of attachment to the crosshead block, however, varies very considerably in accordance with various makers' practices, as will be readily observed from the sketches shown in Fig. 1, which indicate two of the leading types.

The marine type of crosshead on steam engine lines, as shown in this figure, has been practically universally adopted, although, on account of the pressures being much heavier in Diesel engines than in steam, the bearing pins are, of course, much larger. The block itself, with its two bearing pins, is of wrought steel, and the slipper either of cast-iron or of cast-steel with white-metal faces for the ahead and astern guides.

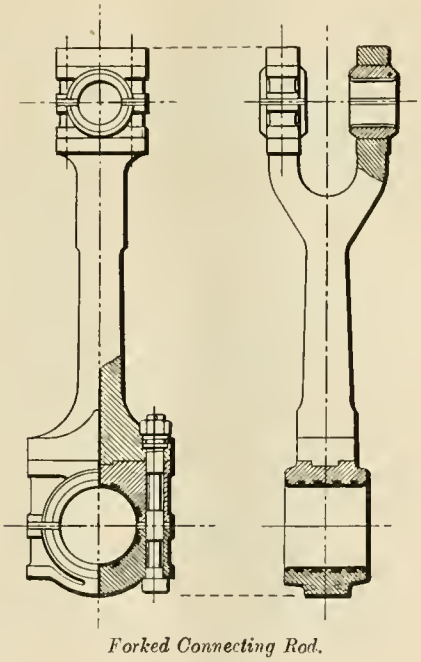
An improved design of block has recently been adopted in which the lower side of the block, which imparts the impulse load to the connecting rod, is made continuous, giving a much larger bearing surface, the connecting rod being designed with a special top end to take the fullest advantage of this additional bearing surface.

The usual type of connecting rod, as shown in Fig. 2, is very similar to the steam standard design, although on the whole of a much more robust character to carry the heavier impulse loads. The bodies are of wrought steel, of circular section, except in certain light type, trunk engines in which H section rods are fitted, the top and bottom bearings having cast-steel shells lined with white-metal. Ready adjustment of the cylinder compression to suit varying conditions and grades of fuels is provided for by the fitting of compression



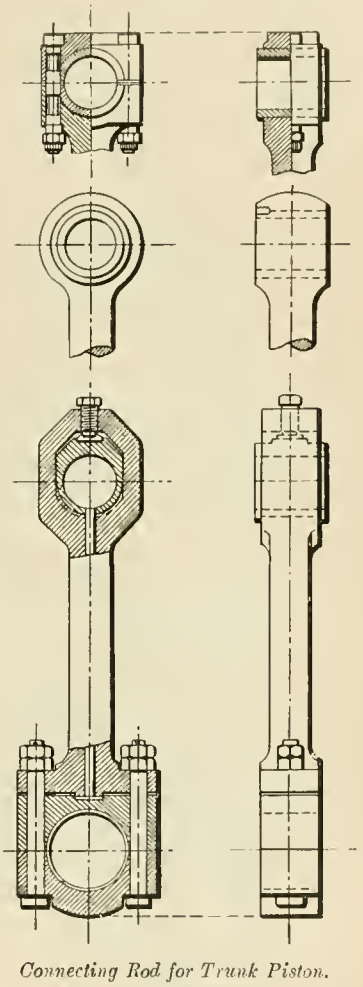
Crosshead and Piston Rod Connection.

Fig. 1.



Forked Connecting Rod.

Fig. 2.



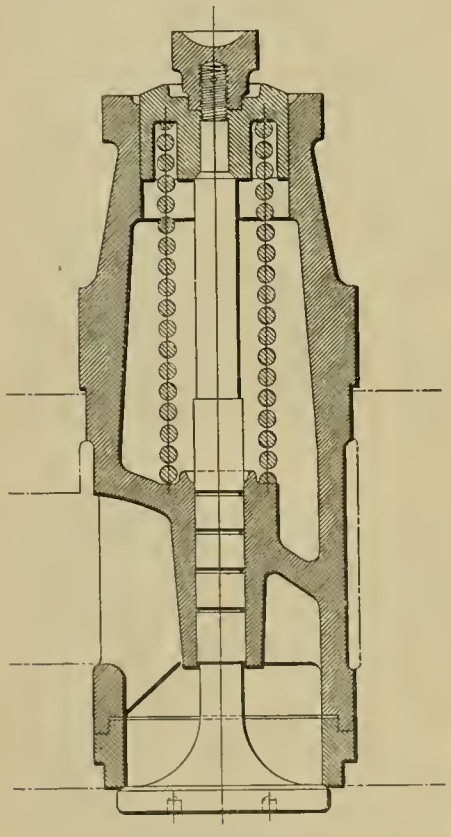
Connecting Rod for Trunk Piston.

Fig. 3.

Constructional Features of Piston Rods, Crossheads and Connecting Rods.

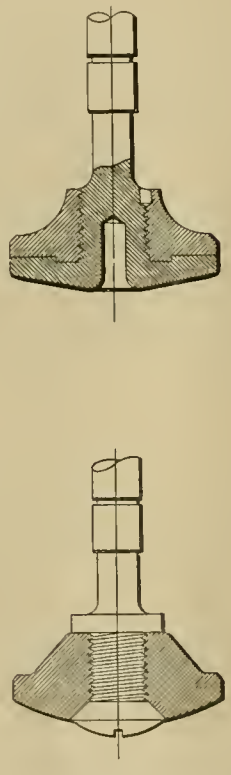
plates between the palm and the bottom-end bearing. Various methods of attachment to the gudgeon pin in the case of trunk-piston engines are illustrated in Fig. 3, although the splitting of the eye and the bush, as shown in one of these examples is impracticable in the smaller size engines where space is very restricted. In designing the connecting rod, the various forces acting upon it must be taken into full account, *e.g.*, compression and bending due to impulse load, bending due to whipping and inertia, tension due to inertia and friction of piston and rings.

The air inlet and exhaust valves, which are principally to be found in four-stroke engines, are housed in cast-iron boxes or cages bolted symmetrically to the cylinder cover on a mitre or flat seat, and embodying a guide for the valve spindle. The upper portion is machined to serve as a guide for the spring cap, which is secured to the valve spindle, a landing being cast between this and the upper portion of the spindle guide for accommodation of the spring. For large engines the exhaust box is water-cooled in way of the spindle guide, the inlet being cooled by the incoming air. A typical air inlet box with valve is shown in Fig. 4.



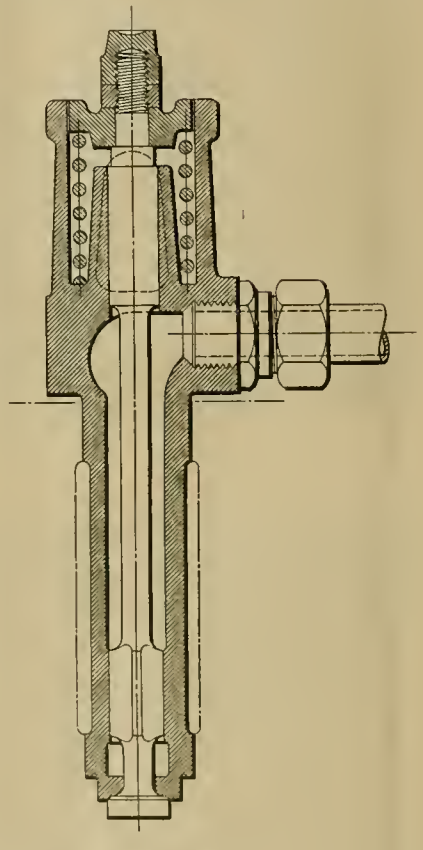
Air Inlet Valve and Box.

Fig. 4.



Valves with Separate Heads.

Fig. 5.



Air Starting Valve.

Fig. 6.

The valves are generally made of wrought steel, but occasionally nickel steel is adopted to avoid pitting. Opinions seem to vary as to the best practice of manufacturing these valves, some makers preferring to make the heads solid with the spindle, while others use cast-iron heads secured to a wrought steel spindle, two methods of attachment being indicated in Fig. 5, the upper sketch being advantageous in having a solid head directly supporting a renewable cast-iron valve. Exhaust valves for large engines are water-cooled.

In practice the size of these valves, to reduce the amount of negative work, will be found to be the largest which can be accommodated in the cover, care being taken to ensure efficient water passages inside the cover surrounding the valve. In this respect the Tosi engine, with its two large common exhaust and inlet valves, has some considerable advantage over the single duty valves.

Where exhaust or scavenge valves in the cylinder head are used in two-stroke engines they are on the same lines as those described above for the four-stroke, although, of course, the usual method is to cut ports in the cylinder liners.

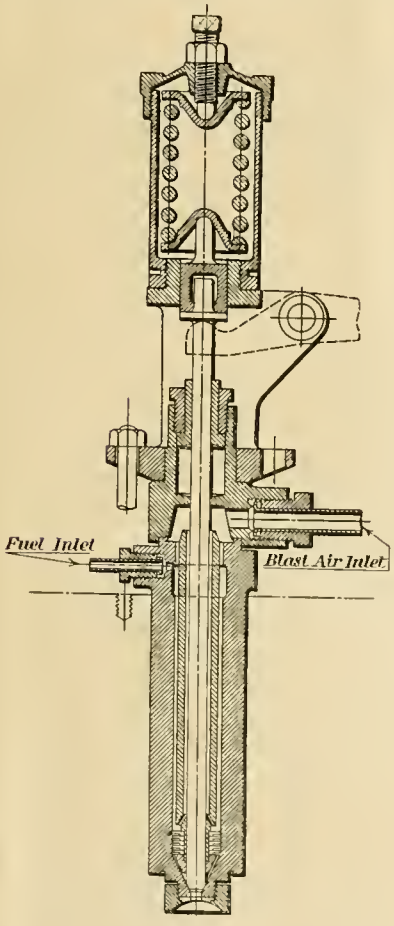
The most common form of air-starting valve is that which is direct-operated and situated in the cylinder cover. Its function is to admit air at a pressure of from 600 lb. per square inch down to, say, 200 lb. per square inch into the cylinder for starting the engine. The simplest form of construction is as shown in Fig. 6, in which one joint only in the cover is necessary, while passages through same are avoided. The valve cage must, of course, be capable of withstanding the full pressure of 600 lb. per square inch, and the spindle a good fit in the guide to prevent excessive air leakage, although, as air starting is only in use for comparatively short periods, special precautions do not appear to be necessary. An alternative system is that in which the valve in the cover is a non-return valve only, the actual timed valve being fitted either in a manifold or in a circular box, the whole of the valves in the latter case being operated by one cam. The usual arrangement is that the timed valves come into operation only when the main air valve controlling the pressure is opened, the valves automatically coming out of action when the main valve is closed.

Relief valves of an ordinary spring-operated non-return type are fitted in the cylinder cover to relieve cylinder pressures above a pre-determined figure, usually in the neighbourhood of about 700 lb. per square inch.

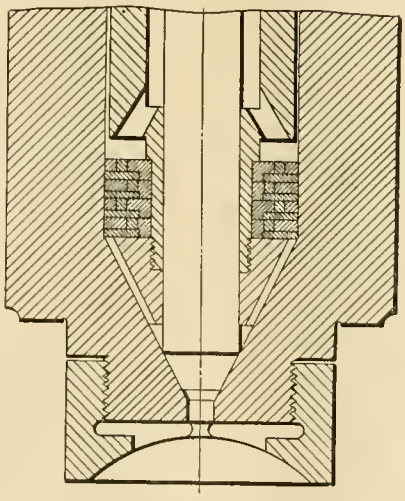
Considerable diversity in design occurs in the case of the fuel valve upon the design and manufacture of which much of the satisfactory operation of the engine depends. The

perfectly atomised fuel necessary for the complete combustion, and consequently the overall consumption of the engine is entirely dependent upon this valve. In air-injection engines air at a pressure of about 1,000 lb. per square inch is used for this purpose, while in solid injection engines the atomisation is accomplished by forcing the oil through one or a number of small holes by means of a pump compressing the oil from 2,000 to 8,000 lb. per square inch or higher.

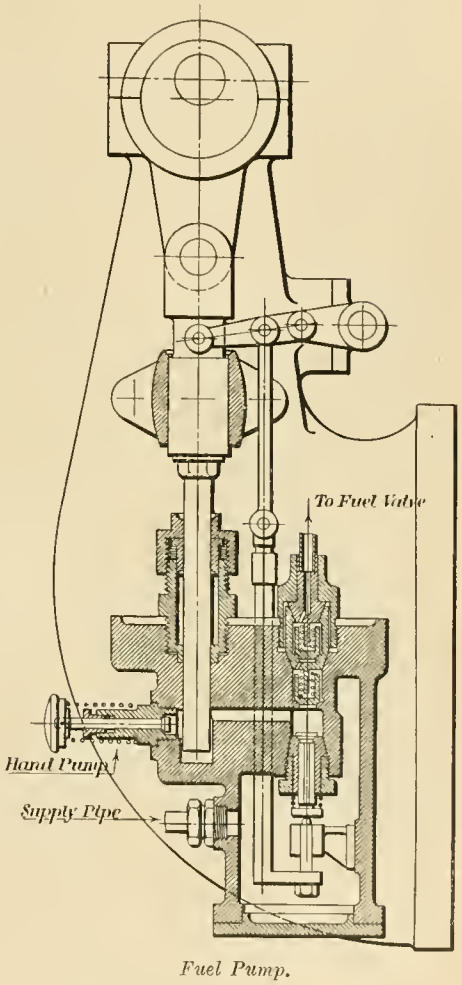
Fig. 7 shows a typical air injection valve, Fig. 8 being an enlarged view of the nozzle end with atomiser plates. This type of valve comprises a cone-seated valve, guided at the top in the main casting and at the bottom in a sleeve, at the lower end of which are secured a number of atomising plates



Fuel Valve.
Fig. 7.



Enlarged View of Atomiser.
Fig. 8.



Fuel Pump.
Fig. 9.

fitted with staggered holes and a fluted cone which fits the valve cage. The valve is cam-operated and is kept on its seat by a powerful spring provided at the top of the valve. The fuel passes down the valve between the cage and the outside diameter of the sleeve, and is collected in a recess on top of the atomiser plates. The air is admitted down the sleeve next to the spindle, and is led directly over the recess, carrying the fuel which it forces through the staggered atomiser plates and the fluted nozzle through the open valve and a flame plate in which is arranged a small diameter hole.

Packing of the glands in these valves is an important consideration, since any tendency to stick would make the operation of the valve sluggish, with consequent dribbling at the needle valve, causing a smoky exhaust. This is, to some extent, obviated in what is termed the flooded type of valve, in which the whole of the casing is under the full fuel pressure and the valve is directly positive in action. The methods of operating this type is by the utilisation of a cross-shaft with a toe under the needle valve nut or by means of a pushrod on to a bell crank lever.

The valves used in solid-injection engines are generally similar in construction to those described above, except that the atomising plates and fluted cones are not required, a nozzle having fine holes being fitted at the lower extremity through which the fuel is forced.

The operation of the fuel valve is effected in a similar manner to that of the air injection.

Another type of solid injection valve, as used on the Still engine, and which appears to be an adaptation of that fitted in some horizontal semi-Diesel land engines, is operated by the pressure of the fuel pump, a small spill valve timing the closing of the fuel valve.

All fuel valves open upwards with the exception of the Burmeister & Wain, which is outstanding as being of the mushroom type.

The function of the fuel oil pump, which is driven by eccentrics from one of the secondary shafts, is to supply the correct quantity of oil to the fuel valve. The quantity dealt with during each stroke is extremely small, and as this is variable to meet the effect of governing, it will be realised that good design and accurate manufacture is essential. Fig. 9 shows a typical pump; the pump plungers and the valves are made of hardened steel or Monel metal, the bodies being of cast-iron. The suction valve is in communication with the control shaft by linkage to regulate the supply of fuel to suit the load, the valve seating at a pre-determined position on the discharge stroke of the pump. To eliminate

any possibility of air locks in the pump, all passages are free from pockets and the suction is fed by gravity from a tank. A floating joint is often adopted between the guide and the plunger to ensure that the plunger and guide are concentric.

In the case of solid injection engines the pumps are called upon to deliver at very high pressures indeed. To meet the much heavier duties required to comply with these conditions, the pump bodies are made of wrought steel or hard bronze with cast-iron plunger sleeves. False seats or cages of cast-iron are usually fitted in combination with steel valves which facilitates grinding-in of the valves and renewal of same.

Some diversity of opinion exists as to whether each cylinder should be fitted with its own independent pump, or whether a common group should be arranged for the engine. Either system seems to work equally well in actual practice.

The high-pressure air of about 1,000 lb. per square inch for use in atomising the fuel and causing turbulence in the cylinder is supplied by a two or three-stage compressor, usually driven from an extension of the forward end of the crankshaft, although it is at times preferred to have it as an independently-driven unit. The three-stage compressor would appear to be the more satisfactory in operation. The proper working of these units is vital to a Diesel installation, as this is obviously the weakest link in the machinery and has in the past been a source of trouble.

Intercoolers are provided between the stages, while an additional cooler and separator is fitted after the passing of the final stage and before entering the blast receivers.

The cylinders are of cast-iron without separate liner, the pistons being also of cast-iron fitted with spring rings, as for the main engine. The final stage piston is usually too small for the standard type of ring to be fitted, and the usual method is to build up the piston with spacing rings and spring rings, the whole being secured by a nut on the piston top.

As leaky valves not only cause excessive heat, but may place undue loads on the lower stage, it is essential that all valves should be readily accessible. The best types are made as light as possible and are usually of the plate type.

The low-pressure scavenge pump, supplying air at a pressure not exceeding 5 lb. per square inch in two-stroke engines, is usually of the piston type, and, if direct-driven by the engine, is usually operated by means of links from the crosshead. Such pumps, however, are rather unwieldy as regards space occupied, and several of the leading two-stroke engine manufacturers have turned their attention to the high speed, electrically-driven, rotary compressor, which effects considerable economy in various directions.

(To be continued.)

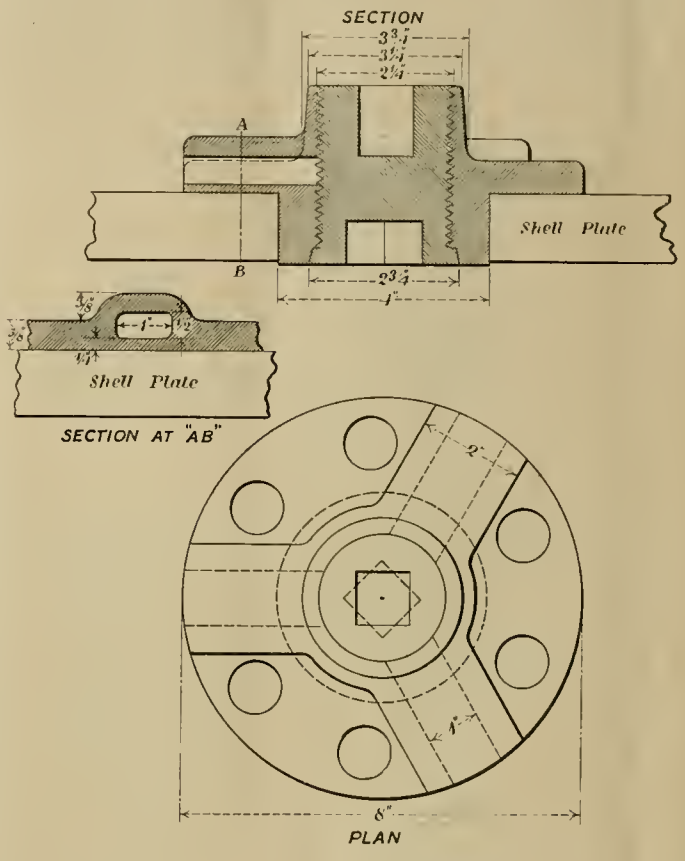
ARRANGEMENTS FOR TANK FILLING AND DRAINING.

On page 95 of the March issue of THE MARINE ENGINEER a method of draining and filling double-bottom ballast tanks was described and illustrated. A correspondent suggests that by fitting an inside pad plate with a tap bolt plug through its centre, over the hole in the tank bottom originally used for water testing purposes, a layer of water corresponding in depth to the thickness of the pad must unavoidably remain in the tank after gravitational draining. This residue of water may be practically eliminated, however, by adopting a special type of drain plug commonly known as a "bleeder," the general design of which is shown in the accompanying sketch.

By providing hoses with ends threaded to correspond with that of the plug, the filling of double-bottom tanks for hydraulic testing is rendered exceptionally easy.

The bleeder is chiefly associated with the oil tanker, where one or more are invariably fitted at the ends of each cargo, oil fuel and double-bottom tank. Where possible they are attached to the outside strakes of bottom shell plating in order that draining may be rendered as complete as possible.

The bleeder consists of two parts, namely, the plug and the plug housing. The former is usually made from gunmetal and the latter from cast-steel, which ensures the minimum of electrolytic action and accompanying corrosion of the shell plating bounding the bleeder. The plug being of gunmetal, threaded four to five threads per inch, also ensures ease of withdrawal after long service. It will be noticed from the sketch plan that three channels, 1 in. × ½ in. are arranged



Arrangement of Tank "Bleeder."

to drain the last dregs of water into the plug-hole after the level in the tank has fallen below the top of the bleeder.

To produce a satisfactory fit all rivet-holes should be drilled and the bleeder casting arranged to project about $\frac{1}{16}$ in. beyond the surface of the shell plating in order to secure a good caulking base. As shown, key-way recesses are arranged at each end of the plug, the one on the outside being used for withdrawing the plug and the other for heaving in the plug from inside the tank after completion of testing and repairs. This is often of appreciable convenience where space between the dock and ship's bottom is limited.

The bleeder can be well recommended for fitting to double-bottom tanks utilised for carrying oil fuel, and will be found of great assistance in draining, prior to cleaning for survey.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The result of the ballot for the election of officers and new Members of Council for 1922–23 of the Institution of Electrical Engineers is as follows:—President, Mr. F. Gill; Vice-Presidents, Dr. W. H. Eccles, F.R.S., Mr. A. A. Campbell Swinton, F.R.S.; Hon. Treasurer, Sir James Devonshire, K.B.E.; ordinary Members of Council: Mr. J. W. Beauchamp, Mr. R. A. Chattock, Mr. F. W. Crawther, Mr. D. N. Dunlop, Major K. Edgcumbe, Mr. A. F. Harmer, Mr. W. R. Rawlings.

SLUICE VALVE WITH SIMPLE REMOTE CONTROL.

Special Application to Oil Fuel Requirements—Positive Emergency Control in Case of Fire—Some Fatigue Tests on Valve Chest.

The increasing use of oil fuel on board ship, and latterly in land installations, has produced many interesting developments. Among others which have been brought to our notice is a very useful sluice valve which has been put on the market by A. Turnbull & Co. Ltd., Bishopbriggs, Glasgow, the well-known valve makers. This valve has been specially designed for oil fuel work to effect an additional safeguard in the event of fire, and its usefulness consists in the facility with which it may be shut from any remote position by the simple operation of pulling a wire rope.

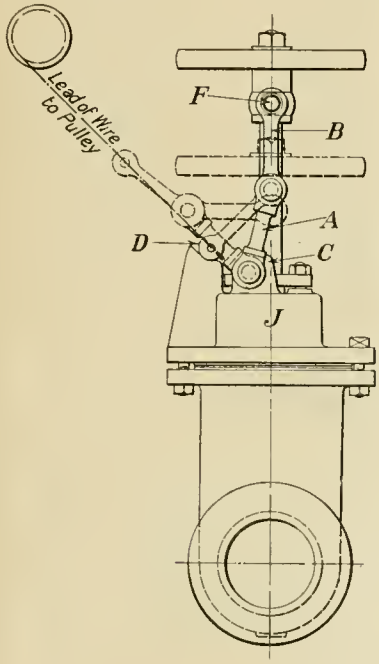


Fig. 1.—Outside Elevation showing Arrangement of Wire Lead.

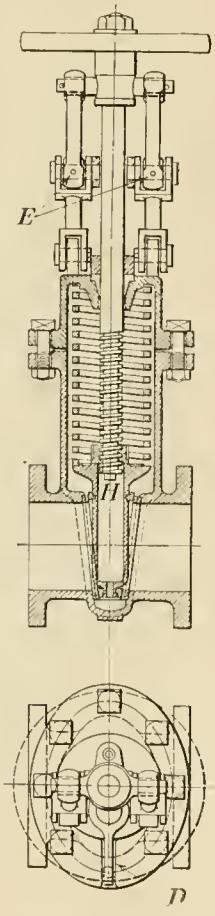


Fig. 2.—Valve and Chest in Section and Plan.

A sluice valve is usually fitted to control the suction flow from deep, oil-fuel, storage and settling tanks, and inasmuch as fires have arisen due to this valve having been inadvertently left open when the suction pipes have been disconnected, it is now one of the Board of Trade Regulations that all such valves should be geared, and the gearing led to a remote position, so that the valve may be securely shut in the event of a fire taking place.

On board ship such gearing has usually to take very awkward and lengthy leads, due to the shape of the machinery spaces and restricted space available, as everyone knows who has had anything to do with the fitting up of such installations. Numerous pairs of bevel wheels and universal joints have to be arranged to get round awkward corners, odd-shaped brackets, specially made, have to be fitted, and the whole of the leads very carefully lined up. This is a very costly part of the work, and even when it is completed the hand-wheel at the end of the gearing, owing to the long leads and numerous sections, is very often exceedingly difficult to operate. Owing to the change in configuration of the structure of a ship due to working in a sea-way, such gearing frequently jambs and has actually to be disconnected to permit the valves to be opened and shut at their respective positions on the tanks, which, of course, renders the emergency safety arrangement inoperative should it ever be required.

The distinctive feature of Turnbull's "Instanter" sluice valve lies in the fact that no gearing is required. The valve for ordinary working purposes is opened and shut by means of the hand-wheel at the valve and is not affected by the emergency shutting device. This means that the valve is continuously operative for shutting in the event of fire or any emergency.

From Figs. 1, 2, 3 and 4 the general construction of the valve will be readily apparent. Fig. 3 shows the valve in the closed position after having been shut by quick-closing mechanism, while Fig. 4 shows the valve in operation as an ordinary sluice valve. Consider the valve to be closed, as shown in Fig. 2. Should it be desired to open the valve by means of the hand-wheel, this is rotated in the ordinary direction (indicated by an arrow cast on the hand-wheel) until the sluice-wedge comes into contact with the bottom of the spindle H, which acts as a stop. The spring is thus compressed until the link A bears against the stop C, the links A and B acting as columns. When it is desired to close the valve from the remote control a pull is imposed on the wire rope which is attached to the link D, this link swinging on loose pins E at the junction of A and B. The tension on the rope causes the links A and B to swing on the centres F and J, and immediately these have passed the dead centers the powerful spring closes the valve instantaneously, and as the hand-wheel, spindle, crosshead and wedge are all in one piece, the wheel moves down to the position shown dotted. To open the valve after it has been closed from the remote control, the hand-wheel must first of all be revolved in the opposite direction as if it were desired to close the valve. This movement raises the spindle out of the nut, thus raising the links, the crosshead and the hand-wheel until they are in the position shown in full on the drawing, with the link A bearing against the stop C and the link B in a vertical position. The valve can now be opened in the usual way by means of the hand-wheel.

It will be observed that this valve cannot be opened from a remote position, but this is considered another valuable point in its favour as regards oil fuel installations. All gear-operated valves can be opened and shut from remote positions, and there is every chance that some careless individual, after closing the valves on account of fire, may start to re-open them before the fire is under control, with disastrous results. This valve is so arranged that once it is closed it cannot be reopened until the engineer in charge can actually approach the valve itself and ascertain that the fire is definitely out and that there is no chance of it re-igniting.

It will be seen, therefore, that the valve can be instantly closed, and the wire controls being placed close together, the whole of the valves in one stokehold can be closed in a few seconds, all lengthy struggling with stiff moving hand-wheels being avoided.

The wire rope is led over small guide pulleys to any desired position, and the whole arrangement can be rapidly and

cheaply fixed in the ship without any lining-up, no fitting being required.

It is claimed by the makers that it is cheaper to fit one of their "Instanter" sluice valves with wires and pulleys than to fit an ordinary sluice valve with extension spindles, mitre wheels and awkward brackets. The valve has been approved by all the registration societies and has been taken up by a great many of the leading shipowners and shipbuilders.

It may be of interest at the present time to state that the largest liner in the world, the White Star *Majestic*, 56,000 tons, was recently fitted at Hamburg with a very complete equipment of these "Instanter" valves, ranging in size from 3½ in. to 6 in., and totalling no fewer than 28 valves in all. Other well-known vessels recently equipped include the *Empress of Scotland*, *Orania* and *Columbia*, in addition to vessels of the Cunard, British Tanker and Commonwealth Government Lines.

Fig. 3.—Valve in Closed Position after having been shut by Quick-Closing Mechanism.

With a view to ascertaining whether the rapid closing of these valves under the action of the heavy spring, had any deleterious effect on the strength and life of the valve chests, exhaustive tests were recently carried out by the manufacturers at the instance of the Board of Trade. These tests were of a very arduous nature, the chest and pipe system containing air instead of oil. This method of testing, it will be evident, gives rise to much more severe conditions than are met with on service, since the cushioning effect of air is very much less than that of oil. Under these conditions the valve was subjected to 50 repeated closings and the chest was subsequently removed to Lloyds' Proving House. The valve was hydraulically forced into its seat until destruction point had been reached, which was accomplished by the wedging action of the valve rupturing the chest. The results of these tests were of a most satisfactory nature and demonstrated that the strength of the chest was in no way affected.

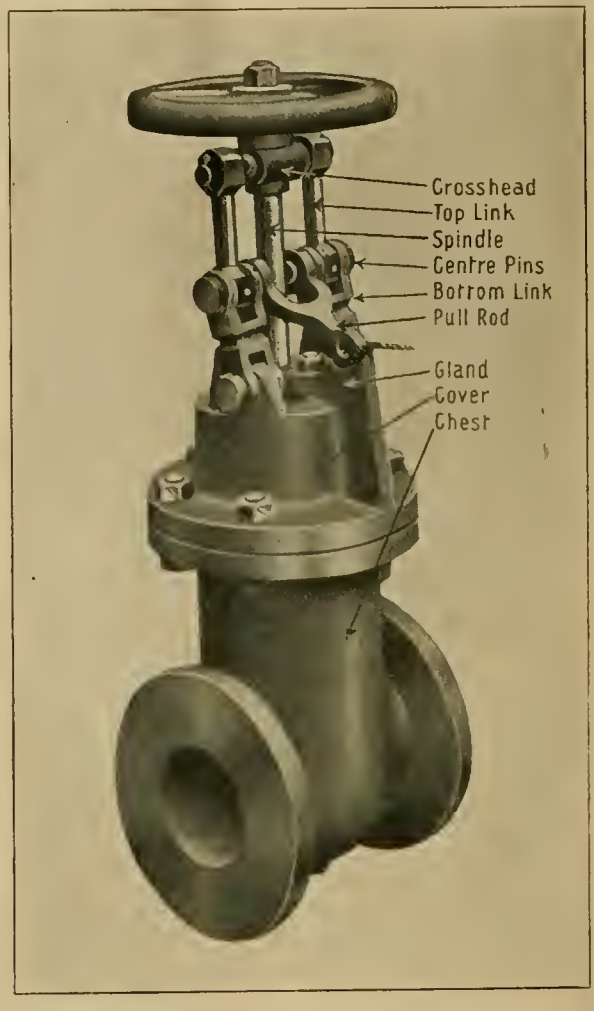


Fig. 4.—Valve Functioning as an Ordinary Sluice Valve.

MOTOR LIFEBOATS.—The lifeboats carried on two of the largest ships in the world, *i.e.*, *Majestic* and *Olympic*, are equipped with Gardner four-cylinder 20 b.h.p. petrol-paraffin engines, supplied by Norris, Henty & Gardners Ltd., of London and Patricroft. These engines are exceedingly popular for this class of work and are highly commended for their reliability, easy starting, clean running and accessibility. Gardner engines for ships' emergency lighting and wireless have an excellent reputation amongst the leading shipping companies, and it is of interest to note that the four latest P. & O. vessels, the *Ballarat*, *Bendigo*, *Barabool*, *Balranald*, referred to in the May issue of the *Marine Engineer*, are equipped with these sets, each consisting of a four-cylinder 48 b.h.p. petrol-paraffin engine, direct coupled to dynamo. In addition to supplying power for wireless and lighting, in case of emergency, they also supply at such a time current for the watertight doors and emergency bilge pumps.

ACTUAL RUNNING COSTS OF MOTORSHIPS.*

Some interesting data relating to the performance of Motor Tonnage on Service.

When the Transatlantic Steamship Company of Gothenburg adopted motorships they selected the Burmeister & Wain four-stroke type of engine. The ships were built and engined by Gôtaverken, of Gothenburg, and constituted this firm's first experience of the construction of motorships, as it also constituted our first experience. These vessels were known as the Bullaren type, and have rendered the company excellent service. They are twin-screw ships of 4,000 i.h.p., and are among the finest and fastest cargo liners in service. Other motorships are under delivery or construction, among the latter being two different types of single-screw ships—one Burmeister & Wain long-stroke and the other Stockholms Atlas-Diesel engines. The company has also contracted for some motorships in England with William Doxford & Son, Sunderland, and are now the owners of the biggest motor single-screw job I so far know of. This ship is the m.s. *Yngaren*, and most of you may have followed her on her long maiden voyage of some 28,000 miles. The sister ship, m.s. *Ekmaren*, will soon be ready for sea. This type has one 3,000 i.h.p. motor, and it provides a good shaft power owing to the absence of compressed air during continuous run, &c.

Some of you may have come here looking for a few consumption figures, and may feel disappointed, but there are so many things of greater importance at present than a few grammes more or less of fuel oil and lubrication oil in this type or that type. Certainly actual consumption has its importance, but to my mind it is discussed sufficiently at present. Moreover, the figures are not always exact, their accuracy depending on the difficulties of securing them sharply when at sea; they are, however, more valuable than the figures with no sea conditions behind them. All good motors are using pretty nearly the same, if they are well looked after, and the oil decent. The shipowner himself and his officials will have to study the internal-combustion problems from various sides and make up their minds as to motor type, quality and number of men, quality and probable price of the fuel-oil they intend to use—and most probably the shipowner will find that, when everything is well prepared for, he will effect considerable savings. Even disregarding the 10 per cent. increased cargo space and, compared with steamers, only a few hours lost in bunkerings, the motorship has a more even speed and a higher average speed on the voyage, while her owners have the pleasure of a good conscience towards coming generations in not having wasted quantities of fuel.

1. M.S. *Bullaren*.—Sydney, Newcastle, Adelaide, Belfast.

Distance by obs.	11,773 miles.
,, ,, eng.	13,374 ,,
Time under way	1,064 hours.
Mean draught	25 ft. 9½ in.
Revs. per minute	97·2.
I.H.P. (twin screws)	3,850.
Average speed by obs.	11·06 knots.
Fuel oil per I.H.P./hour	145 and 142 grams (diff. oils).
,, ,, mile	48·7 and 48 kgs. ,,

The total consumption was :—

Fuel-oil	Kgs. 615,000 (incl. drainage).
Lubricating oil	,, 5,793
Compressor oil	,, 393

Remarks.—This voyage was all right at the start but later on, having got a new fuel-oil, it was found necessary to make several stops for shifting valves. The fuel consumption is perhaps somewhat high per mile, but the ship having spent a long time in tropical waters was foul on the bottom. The lubricating oil consumption is also a little high, but this oil is kept in compartments in the double bottom and now and again this has to be cleaned. In this case one such tank was cleaned and 2,600 kgs. lubricating oil disappeared which are included in the figure 5,793.

2. M.S. *Tisnaren*.—Gothenburg, Cape Town. Maiden voyage.

Distance by obs.	7,231 miles.
,, ,, eng.	8,084 ,,
Time under way	622 hours.
Mean draught	24 ft. 5 in.
Revs. per minute	102.
I.H.P. (twin screws)	4,000.
Average speed by obs.	11·63 knots.
Fuel-oil per I.H.P./hour	147 grams.
,, ,, mile	49·7 kgs.

The total consumption was :—

Fuel-oil	Kgs. 376,000.
Lubricating oil	,, 1,942.
Compressor oil	,, 165.

Remarks.—The cargo was 3,000 stds. Swedish timber for Africa and 1,200 tons general cargo for Java. This voyage was a non-stop run, but the fuel-oil was good. From Africa the *Tisnaren* proceeded to Batavia, average speed 11·49 knots, fuel per i.h.p./hour 147 grammes, fuel per mile 52·37 kgs., i.h.p. 4,150. Mean draught 14 ft. ¾ in. The weather was bad, the governor working almost from port to port.

3. M.S. *Tisnaren* subsequently made several voyages in ballast from Gothenburg to Batavia. They were all equally good and I give here a typical voyage with no stops except those for the Suez Canal. These voyages are of special interest to those who do not find it natural that a twin-screw ship's propellers should have a good chance, particularly when in ballast. In questions like this it is for the owners and their officials to find out which is the more favourable, one or two screws.

Distance by obs.	9,314 miles.
,, ,, eng.	9,382 ,,
Time under way	678·5 hours.
Mean draught (1,000 F. sandball)	13 ft. 11 in.
Revs. per minute	107.
I.H.P. (twin screws)	4,100.
Average speed by obs.	13·72 knots.
Fuel-oil per I.H.P./hour	143 grams.
,, ,, mile	42 kgs.

The total consumption was :—

Fuel-oil	Kgs. 391,188.
Lubricating oil	,, 714. (excl. 900 kg. to tail-shaft)
Compressor oil	Kgs. 249.

Remarks.—On another similar voyage there were several stops, but the average speed was even higher, being 13·76 knots per hour.

4. M.S. *Tisnaren*.—Return voyage, loaded.

Distance by obs.	10,328 miles.
,, ,, eng.	11,932 ,,
Time under way	898·5 hours.
Mean draught	23 ft. 10½ in.
Revs. per minute	102-103.
I.H.P. (twin screws)	4,150.
Average speed by obs.	11·49 knots.
Fuel-oil per I.H.P./hour	151 grams.
,, ,, mile	52 kgs.

The total consumption was :—

Fuel-oil	Kgs. 549,585.
Lubricating oil	,, 3,744.
Compressor oil	,, 265.

In the above voyages, the fuel-oil per mile is for the main motors only. The differences as compared with the total consumption have gone to auxiliary motors or else overboard as drainage from the settling tanks, though on our ships very little is lost in the latter way.

* Abstract of Paper read by Mr. Tage Madsen before the North-East Coast Institution of Engineers and Shipbuilders.

Generally only one auxiliary motor is running; at 90 i.h.p., 300 kgs. a day for this is a good average. The donkey boiler is only used in cold climates for heating cabins, &c., and the consumption is negligible.

5. M.S. *Yngaren*.—Maiden voyage.

The ship first went round to different ports in home waters and consumed about 42·8 kgs. of fuel-oil per mile under half-loaded conditions. The following report covers the trip from Gothenburg to Batavia, via ports in Norway, Germany and England. The figures really start from Hamburg where some fuel-oil was taken on board, the bulk of it eventually being taken on in Brixham. The ship was favourably loaded.

Distance by obs.	8,841 miles.
,, ,, eng.	9,452 ,,
Time under way	816·5 hours.
Mean draught	22 ft.
Revs. per min.	69-70.
I.H.P. (single screw)	3,100 for 7 days, 2,550 rest of time.
Average speed by obs.	10·82 knots.
Fuel-oil per I.H.P. hour	156 grammes.
,, ,, mile	43·1 kgs.

The total consumption was :—

Fuel-oil	404,560 kgs.
Lubricating oil	3,125 ,,

Remarks.—30,000 kgs. of fuel-oil were consumed for the auxiliary motors and donkey boiler. The latter has not been used since Port Said on the outward voyage. The auxiliary motors' average daily consumption is about 430 kgs. per day. The figure is pretty high, but the consumption has not been so perfect. The daily lubricating oil consumption for the main engine is about 67 kgs. and for all other purposes about 25 kgs. These latter figures may be considerably improved. In a new engine there is always much leakage, oil escaping everywhere.

We had eight stops of about 6 hours 55 minutes total time. I will return to them in a more detailed account of the whole maiden trip.

6. From Batavia, *Yngaren* called at Semarang and Soerabaya and went from there to Brisbane.

Distance by obs.	3,101 miles.
,, ,, eng.	3,224 ,,
Time under way	277 hours.
Mean draught	18 ft. 9 in.
Revs. per minute	69-70.
I.H.P. (single screw)	2,550.
Average speed by obs.	11·2 knots.
Fuel-oil per I.H.P./hour	165 grammes.
,, ,, mile	37·62.

The total consumption was :—

Fuel-oil	122,210 kgs.
Lubricating oil	1,485 ,,

Remarks.—The consumption per i.h.p. hour is rather high, the reason being that the sprays had worn, thus impairing combustion. This trip was a non-stop run. From Brisbane the *Yngaren* called at Newcastle, Sydney and Melbourne, consuming, for about five days' run and unloading of the bulk of the cargo, 52 tons of fuel-oil. The whole outward voyage totalled 15,536 miles, the fuel consumption for which was 646,400 kgs. fuel-oil (main engine), or 10·72 tons per day. From Melbourne the *Yngaren* went to Sydney, went into dry-dock and was found to be foul on the bottom as had been expected.

7. In Sydney we loaded part cargo, returning to Melbourne to complete loading. Leaving Melbourne on February 25, we anchored at Dunkirk on April 8.

Distance by obs.	10,963 miles.
,, ,, eng.	12,245 ,,
Time under way	988 hrs. 19 min.
Mean draught	24 ft. 6 in.
Revs. per minute	75·3.
I.H.P. (single screw)	3,050.
Average speed by obs.	11·1 knots.
Fuel-oil per I.H.P./hour	174 grammes.
,, ,, mile	43·6 kgs.

On the whole homeward voyage from Melbourne, 10,963 miles, 478,150 kgs. fuel oil (main engine), or 11·63 tons per day, were consumed.

8. Steamer *Auten*.—Sister hull to m.s. *Yngaren*, 3,000 i.h.p., but closed shelter deck. Maiden voyage, outward :—

Distance by obs.	8,372 miles.
,, ,, eng.	
Time under way	831·6 hours.
Mean draught	27 ft. 1 in.
Revs. per minute	66.
I.H.P. (single screw)	2,400.
Average speed by obs.	10·07 knots.
Coal and oil per I.H.P./hour	
,, ,, ,, mile	139 kg. coal, 28·8 fuel-oil.

The total consumption was :—

Coal	1,163 tons.
Fuel-oil	241 ,,
Lubricating oil	760 kgs.

9. Steamer *Auten*.—Homeward voyage, covering practically the same ground as the *Yngaren* on her present voyage, only that she left from Syndey instead of Melbourne, and arrived at Antwerp instead of Dunkirk.

Distance by obs.	13,408 miles.
,, ,, eng.	
Time under way	1,339·6 hours.
Mean draught	26 ft. 1 in.
Revs. per minute	67·4.
I.H.P. (single screw)	2,450.
Average speed by obs.	10·01 knots.
Coal per I.H.P./hour	
,, mile	201 kgs.

The total consumption was :—

Coal	2,716 tons.
Lubricating oil	1,060 kgs.

Remarks.—On Norfolk-Panama part of the first voyage (8), there were only two boilers in service for a period of 130 hours, the third one being arranged for fuel oil for the run Panama-Wellington. Thus, afterwards there was one boiler on oil and two on coal, consuming respectively 9·5 tons of oil and 30 tons of coal per 24 hours. In reality the boiler was in oil-fired service for 25 days, and it may be of interest to some to know that the *Yngaren*, for example, develops a greater s.h.p. than the *Auten*, when the 9·5 tons of fuel oil are burnt inside *Yngaren's* motor. Thus, what was consumed in the two coal-fired boilers in the case of the *Auten* is absolutely an indisputable saving in the case of *Yngaren*. It should also be observed that the *Auten* carried about 1,400 tons of coal in addition to 322 tons of fuel oil, which oil, burned inside a motor would easily have taken her to the port in question with the same speed. On voyage (9) she started with some 1,500 tons of coal, arrived at Durban with some 360 tons and left Durban again with 1,565 tons, having 159 tons left when the cargo was discharged at the final port. The carrying round the world of these weights and their influence on the cargo-carrying capacity, do not need much explanation to the modern ship-owner.

In the *Bullaren* type we employ : 1 chief engineer, 4 engineers, 1 electrician, 1 turner, 1 blacksmith, 8 motormen. Total, 16 men.

In the *Yngaren* type : 1 chief engineer, 3 engineers, 1 electrician, 1 turner, 1 blacksmith, 6 motormen. Total, 13 men.

In the steamer *Auten* : 1 chief engineer, 3 engineers, 3 greasers, 1 donkeyman, 3 trimmers, 6 firemen, 1 day man. Total, 18 men.

The various figures above can be discussed and looked upon from different sides. It is really unnecessary for me to try to make comparisons, but I hope those interested will see something useful in the above figures.

STABILITY AND TRIM OF VESSELS BURNING OIL FUEL.

Influence of Storage on Metacentric Height—Change of Trim due to Fuel Consumption—Considerations of Design.

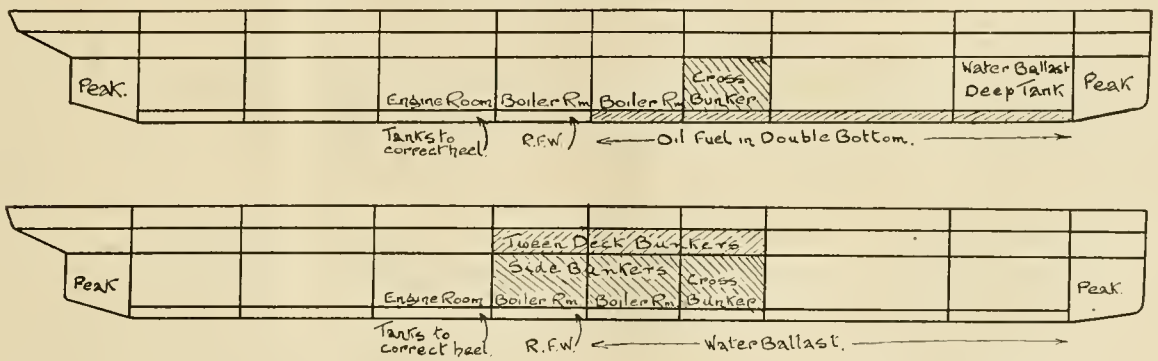
The question of stability and trim of vessels has always been of paramount importance, but that importance has never been greater than it is to-day, particularly for ships using oil fuel. The two great factors influencing the stability and trim, using oil, as compared with coal, are (1) different positions for storage, and (2) free surfaces in oil bunkers when partly empty.

The two profiles below show typical comparisons of disposition of fuel for two similar vessels, one burning oil fuel and the other coal :—

In vessels using coal as fuel, the coal is stored as close as conveniently possible to the boiler rooms, either in side bunkers, cross or 'tween deck bunkers (or a combination of all three). This coal can be used in such a manner that both the stability and trim of the vessel can be maintained by means of double-bottom tanks and peak tanks (dealing with ships in which double bottoms are fitted). As the coal is used, the general tendency is for the centre of gravity of the vessel to rise in the cross bunkers is excessive, suitable longitudinal bulkheads must be constructed (a centre line bulkhead reduces the effect of free surface to one-eighth of its previous value, without the longitudinal subdivision, assuming that only one tank is slack at a time). Or, of course, transverse bulkheads may be introduced, but making one cross bunker into two by means of a transverse bulkhead only reduces the loss to one-half of its previous value.

It is thus seen that vessels coming under the above category of conversion can still be kept quite stable and in good trim by means of the water-ballast tanks.

For vessels designed to burn oil fuel, the case is very different. One of the economic features of using oil fuel is the reduction in space necessary for the stowage of sufficient fuel for a given journey. The oil fuel itself enables this to be done by reason of one ton of oil being capable of producing a greater amount of energy than one ton of coal; also that one ton of oil stows in a capacity of 38 cub. ft., as compared with 45 cub. ft. per



Diagrams showing comparative dispositions of Fuel in Oil and Coal-Burning Vessels of Similar Dimensions.

(except for coal in the 'tween decks). Consequent on this is a reduction in metacentric height, except in vessels where the curve of metacentres rises so rapidly as the draught increases, that for a given coal consumption, the metacentre rises a greater amount than the centre of gravity. This reduction of metacentric height is rectified by filling one or more of the double-bottom tanks. It is also seen from the diagrams that the coal is bunched round about midships, and thus no great alteration in trim takes place as the coal is consumed.

The case of oil-fuel ships presents a problem considerably more complex. Firstly, we will deal with vessels which have been converted from coal-burners to oil-burners, and then pass on to vessels designed originally to use oil fuel. In many conversions, the existing coal bunkers have been renovated and stiffened, and oil fuel is now carried in those same bunkers. Where this has been done, the whole of the double-bottom tanks (originally used for water ballast) are still available for water ballast to increase stability and rectify trim, and the problem is similar to that described for vessels using coal.

In this case also, the side bunkers (bunkers abreast engine and boiler rooms) are not of sufficient breadth to have any appreciable effect on the metacentric height, owing to the free surface of oil when the bunker is partly emptied. If it is found that the loss of metacentric height due to free surface ton of coal. In addition to this, however, to increase still further the cargo space available, oil fuel may be carried in the double bottoms. This is the usual practice nowadays, a portion of the oil being carried in the double bottoms, the remainder being stored in cross bunkers.

This arrangement is almost certain to ensure a good metacentric height in the vessel's loaded condition, owing to a large amount of weight being situated low down in the ship; but as will be seen later, it is quite an easy matter to encounter difficulties when the vessel is floating comparatively light.

The usual procedure for burning oil fuel in vessels fitted with a large cross bunker and double-bottom tanks, is to use the oil from the bottom tanks first (these, of course, being of much smaller capacity than the cross bunker as a rule), and then, when calling at a port, to empty the cross bunker oil into the double-bottom tanks to use from when at sea. This allows the cross bunker to be kept pressed up while at sea, and so avoids the danger of having a large free surface, and large amount of oil rolling about when the vessel is pitching. Of course, as stated before, this danger could be reduced by fitting extra bulkheads in the bunker, but if the bunker be a large one, a single centre-line divisional bulkhead creates a further trouble. It reduces the loss in metacentric height, but it opens up the possibility of a very large angle of heel in the case when the bunker is empty and one side accidentally bilged.

As the oil fuel is used from the double-bottom tanks, the centre of gravity of vessel rises, and if any more tanks are available for water ballast, these can be filled to keep a safe margin of stability. Difficulty arises, however, owing to the fact of not being able to use the oil fuel tanks (when emptied) for water ballast. In a number of large vessels this difficulty has occurred, and stone ballast has been used to ensure stability and trim in all conditions of loading.

With regard to the trim of the ship, trouble is again experienced by not being able to use oil-fuel double-bottom tanks for water ballast. As it is convenient to have the reserve feed tanks near the boiler room (to save long pipes and connections) and the fact that two tanks, one port and one starboard, are usually arranged somewhere aft (near to the pumps), for correcting the list of the ship as fuel, stores, &c., are consumed, it will be seen that in the large majority of cases the double-bottom tanks for the storage of oil fuel will be forward. Thus, as oil is consumed the vessel will trim by the stern, and in many cases it is impossible to correct this trim by means of the fore peak tank and any double-bottom water ballast tanks forward. In these cases large water ballast deep tanks have had to be fitted forward for this purpose. Here again, if the deep tank has to be large, there is the difficulty of filling it while at sea, and attempts should always be made to fill this tank in smooth water. If the tank will be required to be full at the end of a certain voyage, arrange to fill it at the last port of call.

It is thus seen that the design of a vessel to burn coal, and that of one to burn oil fuel, are two very different problems. When a designer is faced with these difficulties it is not sufficient to work on a comparison of an older vessel's characteristics when designing an oil-fuel ship. Allowance must always be made to ensure a safe stability and trim in all cases. For a new ship to burn oil fuel, it is always safe to put 6 in. or 1 ft. on to the beam as compared with a similar vessel burning coal. This raises the metacentre, and the stability in the lighter conditions will be considerably improved.

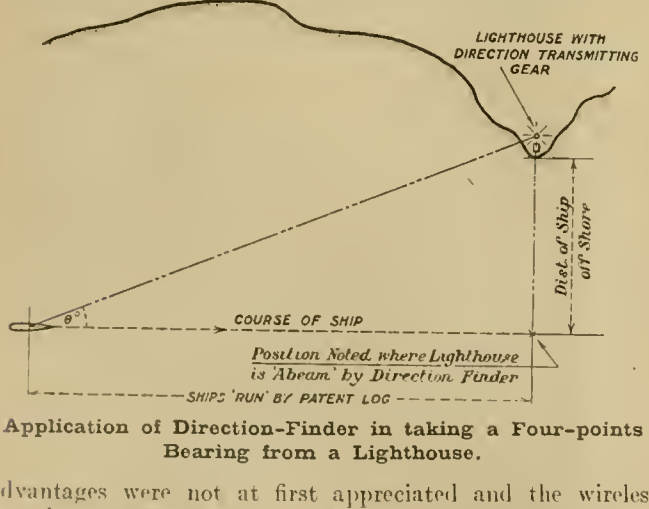
Of course, there is always the "excessive stability" to be guarded against in the loaded condition, by having too large a metacentric height, but this can almost always be arranged for by the captain of the ship during loading operations, by putting the heavy cargo in the 'tween decks, and the less dense cargo in the holds.

MODERN NAVIGATION.

Progress in Wireless Telegraphy—The Wireless Direction Finder—Application of the "Leader" Cable—Science as an Aid to Navigation.

The art of navigation is being brought year by year further within the boundaries of applied science, and at the present day the research of the electrician and the physicist is aiding the navigator to such an extent that it seems possible to predict in the by no means distant future that the sailor as we know him at present will become transformed into a species of super-technician.

By far the most important step in this direction the present century has seen is the invention of wireless telegraphy and its application to marine work. As has been the case with a great many discoveries of a revolutionary character, its


LIGHTHOUSE WITH DIRECTION TRANSMITTING GEAR
Dist. of Ship off Shore
θ°
COURSE OF SHIP
Position Noted where Lighthouse is 'Abeam' by Direction Finder
SHIPS 'RUN' BY PATENT LOG

Application of Direction-Finder in taking a Four-points Bearing from a Lighthouse.

advantages were not at first appreciated and the wireless experimenter was regarded as a sort of harmless enthusiast whilst the operators, carried on those ships whose owners were far seeing enough to provide installations before such were made compulsory, were considered by many ship captains as an unmitigated encumbrance.

It is interesting to note in passing that the United States Government was amongst the first to realise the advantages of fitting wireless telegraphy to ships, and in a law which became operative on July 1, 1911, it was made compulsory for all ships to carry installations under certain conditions, which have of course been brought up to date to satisfy modern requirements.

When wireless telegraphy had become a definitely established part of ships' equipments it was only natural that its development should be rapid and many useful adaptions were brought into use which to-day are of the greatest utility to navigators; in the first rank amongst these applications are the wireless telegraphy time signals which are sent out at specified hours by most of the important land stations all over the world; by means of these signals, the navigator is enabled accurately to check his chronometer and in calculating his noon position is certain of working correctly with the particular standard time in use; the great advantage of this can be realised when it is remembered what an important part is played by the chronometer in the calculations which determine the ship's position.

Another almost equally important function of wireless telegraphy in modern navigation is the sending out of reports forecasting the state of the weather and emphasising any unusual depressions or disturbances, so that, by noting the probable position of bad weather mentioned in these reports, a ship's captain can regulate his course so as to clear the danger zone; these wireless weather reports are also sent out at certain definite hours by most of the big land stations, and in this connection should be mentioned, of course, the very valuable ice warnings which are issued from the Cape Race station and give notice of the probable position of "bergs" and "growlers" in the vicinity of the treacherous Grand Banks of Newfoundland; this station obtains much of its information from the masters of ships, who make a direct report of the position and characteristics of any ice they happen to pass; it also works hand-in-hand with the United States coastguard cutters which are stationed in these waters, and maintain the International Ice Patrol there.*

By carefully watching his ice reports a captain can very often save a hundred miles or so on his journey—steering further north in safety, with the knowledge at his disposal, than he would otherwise have felt justified in doing.

Wireless telegraphy has also the additional advantage (or disadvantage!) of enabling owners to keep in direct communi-

* A point of technical shipbuilding interest occurs here in the fact that the United States Government has recently placed on this station one of their latest electrically controlled revenue cutters, because this type of machinery gives her such excellent powers of reversing and manœuvring.

cation with their fleets. This is useful for instance in the case of " tramps " running " light " to America from this side of the Atlantic—such ships can be easily diverted to any port where an exceptionally good cargo offers by means of a " radio " message from one of the big home stations.

A recent very important departure in wireless telegraphy is the introduction of directional wireless which is of two distinct types :—

(*a*) Directional stations established on shore.

(*b*) The wireless direction finder as fitted on board ship.

In case (*a*) the direction finding apparatus is situated in a shore station, and the ship which requires to know its position calls up the station, which, in turn, by means of its direction finding apparatus, is enabled to signal the information.

Sometimes the practice is for the ship to call up two stations only and then to use the cross bearing, but a better result can be obtained if communication is established with three stations, because then a traingle can be marked off on the chart with the three bearings—the centroid of which is a much more accurate value of the ship's position than that which is obtained by the intersection of two bearings—this triangle is known usually as " a triangle of error " or " cocked hat." In 1921 there were two main types of these shore stations in use—each direction-finding station fitted with receiving and transmitting gear and working as an independent unit, or several stations near a particularly difficult channel passage having receiving gear but not transmitting gear ; these latter are linked together by special land-telegraph lines and are controlled by one master station which has the transmitting apparatus. Wireless direction finding arrangements are extremely useful in foggy weather for vessels approaching rocky coasts, as they can get their positions at a much greater distance from the coast than would be possible otherwise.

In case (*b*) the apparatus is usually fitted as a separate unit, and consists of two coils at right angles to each other in a vertical plane—the coils are constructed to rotate in a horizontal plane and the operator does this until he finds the position in which he hears the note from the transmitting station as a maximum, and then, by noting the angular displacement of the coils from the zero position, the bearing of the transmitting station can be determined ; the advantages of this installation are considerable because its uses are not necessarily restricted to " ship-shore " work—in fact, its use is just as great for intercommunication between ships as has been proved in two cases recently, where one ship in danger of sinking, sent out wireless calls for help, which were picked up by another vessel carrying direction-finding apparatus, whose navigating officers, by means of the " wireless bearing " supplied, were able to find the distressed vessel, and furthermore they discovered in one case that the actual position of the ship, as determined by the direction-finder, was many miles different from that which had been calculated. The direction-finder is capable of development in a great many ways, and it will be of great value if developed as a sort of " wireless syren " for navigation in foggy weather in congested waterways—for example, a vessel could send a note on a short wave length fairly frequently—somewhat after the same manner as that in which the steam syren is ordinarily used in fog, and all ships in the vicinity " listening in " and rotating their coils could then obtain the bearing of their neighbour and, if necessary, alter course accordingly. The direction-finder lends itself very readily to the comparatively simple operation of taking a " four-points " bearing in thick weather from a lighthouse or lightship fitted with transmitting apparatus, and the readings can then be worked in conjunction with the patent log readings. A possible disadvantage, as is the case with a great many otherwise highly useful inventions at the present time, is initial cost ; owners, it would seem, bearing in mind the present high price of tonnage, are not willing to go to the further expense of fitting their vessels with these " extras," however useful or efficient they may appear at first sight, and in point of fact, comparatively few merchant ships are fitted with the direction-finder—about as great a percentage perhaps as is fitted with apparatus for picking up submarine sound signals—another very useful application of science to navigation. As is well known the successful propagation of sound waves in a foggy atmosphere is a very difficult matter owing, according to one theory, to the refraction and reflection of the sound waves on belts of atmosphere of different densities. Sound waves, however, travel in water with much greater ease and the sound of a bell struck underwater can be picked up with perfect ease by means of receivers fitted to the skin of the ship and connected to the bridge. In practice, however, it is often found quite possible in vessels not fitted with receiving apparatus to hear the sound of a submarine bell by going down into the fore peak and listening against the ship's side ; but, of course, with the general introduction and gradual perfection of the above-mentioned wireless methods the need for the submarine bell will probably gradually disappear.

The leader cable as yet has not been very largely adopted for general navigational purposes, it was used during the war for naval work, and some very instructive experiments have been carried out in the Ambrose Channel, New York, by the American naval authorities, and in January of this year a scheme was under consideration by the Havre Chamber of Commerce for the establishment of a guiding cable running out from the port to the Cap de la Heve lightship, and then parallel with the coast up to Cap d'Antifer,—the alternator for supplying current to the cable was to be carried in the lightship ; the chief uses of such a cable, of course, are in foggy weather, and it has been pointed out in this connection that fogs are somewhat rare in this part of the French coast, but the authorities apparently considered that, in any case, a great saving of time will be effected in the time taken for a vessel to reach port ; for cross-channel runs, too, the cable has been suggested as extremely useful as a saver of time from port to port, but up to the present the suggestion does not seem to have been put into use. For estuaries, the cable should prove a great boon for navigation in thick weather, with separate cables for " in " and " out " traffic ; a disadvantage, of course, is the cost, both initial and that of upkeep ; this, in time, might be defrayed by levying a due on all shipping using the cable, although it seems perhaps rather venturesome to predict that even when more developed it will be the means of dispensing with pilots ; for very sandy estuaries, in which there is a continual movement of sand and much dredging, there seems to be a likelihood that the cable may move unless very firmly anchored to the bottom.

With regard to general navigation improvements, an extremely useful addition has been made in the Behm Echolot, an automatic sounder of German origin, recently reviewed in this journal, depending for its principle upon the velocity of sound in water.

The gyroscopic compass is an extremely useful and interesting application of science to seamanship, and, of course, the most important of its many advantages is that it is not affected in any way by magnetism. It is claimed, in fact, for the " Brown " gyro compass—the only British Gyro Compass—that a course can be steered to within one degree, that bearings can be laid off direct from compass to chart, and that a material saving of fuel results from this.

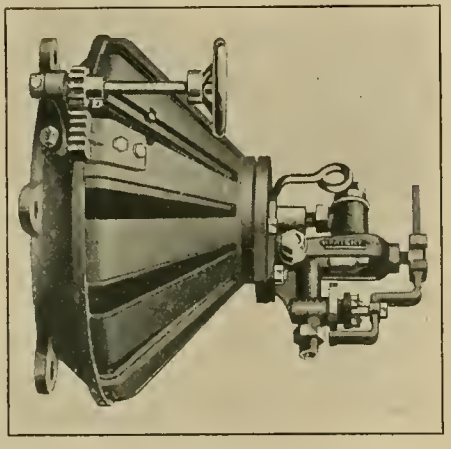
Mention should also be made of the saving of time and extreme handiness of patent logs which have their dials fitted in the chart house so that it is possible for the officer of the watch to read off in the chart house instead of sending a man aft to the taffrail every time a reading is required.

In the above, some of the more recent and more important improvements to the science of navigation have been mentioned. No attempt has been made to discuss them in detail, but rather a general survey has been intended with a view to showing that, hand-in hand with developments in the design and construction of ships, improvements are also being made in the methods employed in working them.

CUNARDER "BERENGARIA" CONVERTED TO OIL-FUEL BURNING.

Work of Conversion by Sir W. G. Armstrong, Whitworth & Co. Ltd., Walker-on-Tyne—"White" Low-Pressure Oil-Burning System by the White Patent Oil Fuel Co.—Largest Boiler Repair Contract ever carried out on the Tyne—General Reconditioning and Overhaul.

With the conversion of the *Berengaria* from coal to oil-burning the Cunard Steamship Company have now, with the *Aquitania* and *Mauretania*, three oil-burning vessels, representing a combined gross tonnage of over 120,000, and these vessels are together capable of accommodating fully 7,000 passengers. The *Berengaria* has rejoined the *Aquitania* and *Mauretania* in the company's express service between Southampton, Cherbourg and New York, and took up her first sailing of the season from Southampton on May 20. To those who have feared that Neptune's trident might pass into other hands it may come as a surprise to realise that not only the Cunard, but several other British companies, are to-day, in point of large ships and fine tonnage, in a stronger position relatively than at any previous time in their history. The *Berengaria* arrived on the Tyne for conversion on October 31, 1921, and left the Tyne, subsequent to the completion of that work, on April 26 of this year.



White Patent Conical Hand-controlled Air Regulator.

Some indication of the amount of work involved in the conversion will be conveyed when it is realised that a period of some six months was occupied. The principal dimensions of the *Berengaria* are as follow:—

Length, o.a.	919 ft.
Breadth, moulded	99 ft. 4 in.
Depth, moulded	62 ft.
Depth from boat deck	100 ft.
Keel to truck	246 ft.
Gross tonnage	52,000 tons.
Displacement	65,000 tons.

The vessel is larger than the *Aquitania*, which recently left the Armstrong Naval Yard after a similar conversion, and is therefore the largest vessel which has ever visited the Tyne. During the vessel's sojourn of six months on the Tyne she has undergone conversion, complete overhaul and reconditioning at the Walker Yard of Sir W. G. Armstrong, Whitworth & Co. Limited, who were also responsible for similar work on the *Aquitania*.

Boiler Rooms before Conversion.

Steam is generated in 46 boilers of the Yarrow water-tube type, arranged three abreast in 4 boiler rooms, of which Nos. 2, 3 and 4 each contain 12 boilers, 6 boilers being placed back to back at the centre and separated by double stokeholds from 3 boilers ranged along each athwartship bulkhead, as illustrated in the plate-drawing which we reproduce with this issue. The forward boiler room, known as No. 1, contains the remaining 10 boilers similarly arranged, except that only one boiler is placed amidships at the forward athwartship bulkhead. All stokeholds are connected by passageways between the boilers. The *Berengaria* is the first large passenger liner in the British merchant service to be fully equipped with water-tube boilers, although such installations are a common feature in vessels of the Royal Navy. We also show in the plate-drawing the general arrangement of coal bunkers and boiler rooms which obtained prior to the conversion.

Tank Storage Arrangements.

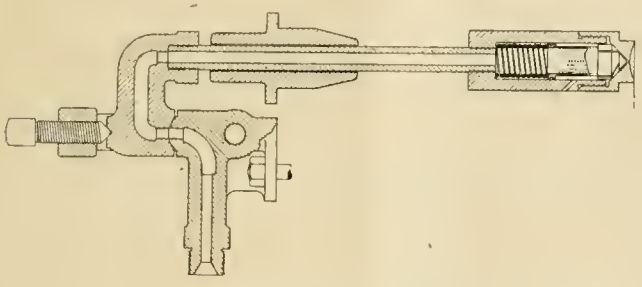
The oil fuel is carried in tanks forming part of the vessel's structure, running for a length of about 300 ft. on either side of the boiler rooms and occupying the space previously utilised for coal bunkers. This vessel, like the *Mauretania*, differs from the *Aquitania*, inasmuch as no oil-fuel is carried in the double bottom tanks. A fuel capacity of 6,200 tons has been provided, and this is accommodated in 32 tanks, *i.e.*, 24 storage and eight settling tanks. This quantity of oil is estimated adequately to meet the requirements for one trip across the Atlantic, with a substantial margin for safety in case of delays arising from heavy weather and other circumstances unforeseen. In providing this tank capacity a considerable amount of structural work was involved. All ash-ejectors, hoists, bunker doors, &c., were removed, and the structure made suitable for the special conditions associated with the carriage and burning of oil-fuel. At the commencement of the voyage all tanks are filled, with the exception A.3 starboard and B.3 port tanks which are kept slack for overflow purposes, as shown on the plate-drawing. There are two settling tanks in each boiler room, one tank being used for supplying oil to the boilers, while the other is laid off for settling purposes—under heat, if necessary.

Heating coils of 2-in. solid drawn steel tube are provided in all tanks. In the storage tanks the coils are provided so that the fuel may be sufficiently fluid for pumping in the coldest weather. In the settling tanks the heating coils serve to separate the water from the oil, and this water, falling to the lower sections of the tank, is drained off to the bilges. As a general rule it may be said that the fuel is taken aboard at a temperature of 100 deg. to 110 deg. F., and as the temperature of the boiler room wings in the vicinity of the storage tanks is not likely to be less than this temperature it is not anticipated that, under normal conditions of working, it will prove necessary to utilise the heating coils provided in the storage tanks. A special feature of the heating coils is the absence of joints inside the tanks so that the danger of leakage is reduced to a minimum. The heating steam, when required, is taken from the auxiliary steam range and is reduced to 50 lbs. per square inch pressure before entering the coils. Condensation in the coils is relieved by discharging the condensed steam through steam traps into observation tanks where the immunity of the condensed steam from oil is fully established before the water is allowed to return to the reserve feed tank. From this tank the water is pumped to the main engine hotwell tanks and thence to the boilers, or, alternatively, direct to the boilers by means of the auxiliary feed pumps.

Filling Stations and Pipe System.

Four filling stations are provided—two on the port side and two on the starboard side—and all stations are situate on "G" deck. Reference to the plate-drawing will convey a general impression of the piping arrangement which is such that the vessel may be fuelled from either the port or the starboard side or from both sides simultaneously. On page 244 will be found an inboard view of the starboard after filling station, which may be taken to be representative. A large capacity filter is incorporated in each filling main to

guard against the intrusion of foreign matter in the system. In the event of an excess pressure being set up when the vessel is fuelling from an external pumping source, a relief valve is provided at each filling station and a 4-in. pipe by-passes any excess fuel to the common air and overflow pipe and thence to the overflow reservoir. Should this reservoir become filled and an excess pressure be set up, relief is obtained through an overflow pipe led from the tank through a non-return and storm-valve over the ship's side above the water line. From the highest point in the air and overflow system a pipe is led up the funnel hatch to the open air. It frequently occurs that the fuelling barge has no steam supply to her pumping set, and to meet this a permanent steam main is led to the ship's filling station and connection is made to the barge pumps. An obvious advantage from this



The White Patent Oil-Fuel Burner.

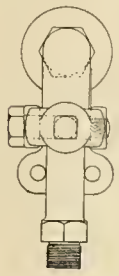
arrangement is that the filling operation is completely under the control of the ship's operator without reference to the barge.

To facilitate the filling of the storage tanks, heavy glass gauges are provided at the upper sections of each tank, and a float alarm indicator is also incorporated. A complete system of Pneumercator gauges has been fitted, these being arranged in batteries of five gauges situate in the forward section of each boiler room. By means of a two-way cock this battery of gauges registers the quantity of fuel in eight tanks. A ring main, consisting of 8-in. lap-welded steel piping, is carried right round the boiler rooms with cross connections in each boiler room and connections to each tank for filling and transfer purposes. For the transfer of the oil from the storage to the settling tanks, one large vertical Weir's transfer pump has been provided in each boiler room, each pump having a capacity of 100 tons per hour.

Weir's unit pumps, which discharge the oil to the burners, normally take their supply from the settling tanks, but provision is made whereby these pumps may also draw from the storage tanks direct. Such is the arrangement of piping that the failure of one compartment will not prejudice the working of the system as a whole.

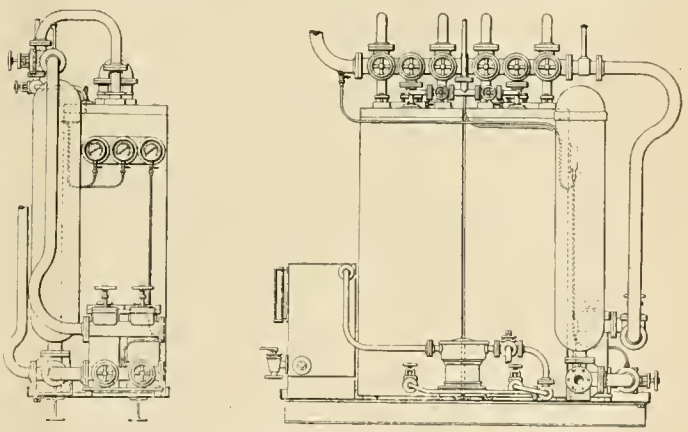
Oil Burning Equipment.

The oil burning installation adopted in the *Berengaria* is on the White low-pressure system, the plant having been supplied by the White Patent Oil Burning Company, Pearl Buildings, Newcastle-on-Tyne. It should be stated that the White Company have also been responsible for similar oil-burning installations on the *Aquitania* and on the White Star liners *Olympic* and *Majestic*. From the photographs and drawings included in this issue, the general arrangement of furnace fronts will be readily followed. Each boiler is fitted with five oil burners with air regulators, making a total of 230 burners. We illustrate above the White patent burner, a special feature of which is the ease and rapidity with which it may be changed and replaced. The burner fits into the conical front, and is held in position by means of a swinging shackle, pivoted to a casting which is secured to the furnace front. The joint between this casting and the burner is of the metal-to-metal type, and is kept oil-tight by a pointed set-screw carried by the swinging shackle. By the one operation of slacking back this set-screw and swinging the shackle clear, the burner is free for removal for cleaning or examination. The oil-burning installation consists of four complete sets of machinery, one for each boiler room, identical in detail and arrangement, each set comprising three separate units, two units being fitted in one boiler room, and one in the other. The machinery for each boiler room is entirely isolated from that in the adjoining compartment, but the separate units for each room are cross-connected, so that any combination can be arranged, two units being of sufficient capacity to supply the whole of the burners in their respective boiler rooms, under full power conditions, the third unit being held in reserve. The heaters are fitted in pairs on oil-tight trays, each heater being of sufficient capacity to allow of one heater of each pair remaining shut down while the other is in service.



To meet the exigencies of confined floor space, the units are subdivided as follows : two heaters, one discharge filter chest, one observation tank for heater drains, steam trap and air vessel are arranged together on one oil-tight tray, forming what is termed a heater tray, and shown in the drawing below. Weir's horizontal oil-fuel pump, and one suction filter chest are placed on a second oil-tight tray, termed a pump tray. Where two units are arranged in a common boiler room, the pumps and suction filter chests of each are assembled in duplicate on one oil-tight tray.

It will be seen that the units are arranged midway between the boiler fronts on seatings built up from the double-bottom tank top, while the heater trays are in all cases in the wings, with the pump trays at 'midships, and level with the stokehold floors. The necessary pipe connections between the pumps



Arrangement of Heater Tray.

and heaters are arranged under the stokehold gratings. The pumps and suction filter chests for each unit in the double unit section of each boiler room are placed in the most convenient relative positions on the common tray to allow of complete overhaul, and a similar arrangement is carried out for the single-unit pump and suction filter.

The suction filter, through which the oil is drawn from the settling tanks, is of the twin type, so that one compartment may be opened up for cleaning while the other is at work, the covers being held in place by separate quick-detachable yokes. The test pressure of these filters is 200 lb. per sq. inch.

The oil-fuel heaters are arranged in pairs and each heater contains two concentric coils of seamless steel tubing, the four ends of which pass through stuffing boxes and steel glands provided on the cover. The inlet and outlet pipes are connected by steel bends to the header valve chest, while the intermediate ends are joined by a short bend so that the oil, after passing through one of the coils, is led over into the

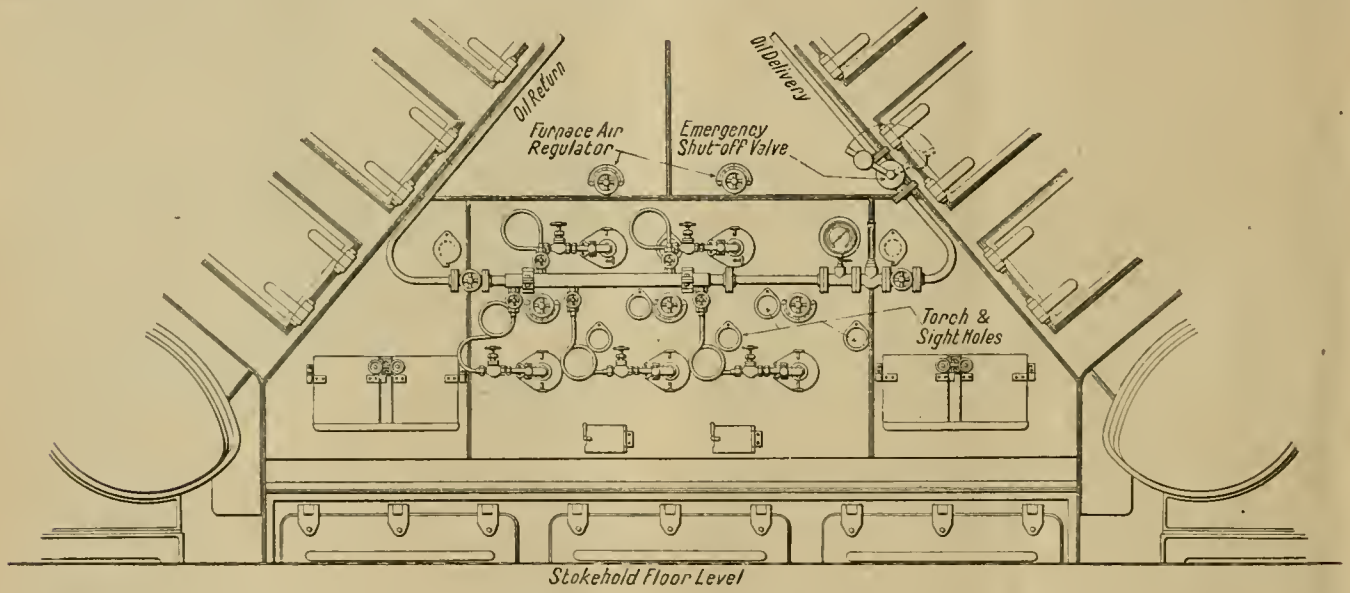
second coil, thence to the outlet header valve and subsequently through the discharge filters to the burners.

Steam is admitted to the heater through a connection at the top and passed out at the bottom drain to the steam trap, and from thence to the observation drain tank. The discharge filters, fitted between the heaters and the burners, are of the twin type, and generally similar in construction to that of the suction filters already described, the main difference being that they are of heavier construction to withstand the greater working pressure, and that the covers are secured in place by studs, the test pressure of these filters being 420 lb. per sq. inch. A solid-drawn steel air vessel, secured on a cast-steel base is provided and is of ample capacity to ensure a non-fluctuating flow of oil to the burners. Steam and oil pressure gauges are fitted in prominent positions to facilitate supervision and control, and special care has been taken to ensure that all parts are accessible for easy working and overhaul.

Combustion and Draught Control.

The ventilation of the boiler rooms, as originally arranged for coal-burning, was not considered as likely to be productive of the best results under the modified conditions. It was, therefore, decided to adopt the closed-stokehold system of forced draught, and for this purpose the existing forced draught and ventilating fans were used. The introduction of the closed stokehold system involved additional structural alterations in the shape of special air-locks, hinged covers, &c., so that the air pressure might at all times be maintained. The oil burners are an improved design of the conical air-regulating type, supported on a steel casing, lined with fire bricks, which, in turn, is rigidly secured to the inner boiler casing plates. A sleeve passed through the boiler outer casing plate acts as a support for the fronts and forms an efficient air-tight joint. Pre-heating and control of the air supply is all-important in order to obtain complete combustion of the fuel and thereby gain the highest state of efficiency with the elimination of smoke and deposits in the boiler. One of the main features of the oil burners is the arrangement for regulating the supply of air to the oil sprays. Air inlets are arranged round the periphery of the body casting, over which a cover is fitted having a corresponding number of slots, as shown on page 236. This cover is free to revolve, and is operated by a rack and pinion, so that the air inlets can be opened or closed as desired. An engraved plate and pointer, arranged on the boiler front casing, registers the exact air admission given. The hot air supply, in passing through the air slots, is given a rotary motion by means of a further arrangement of internal vanes, thus ensuring an intimate and thorough admixture of air and oil, resulting in perfect combustion. Special attention has been given to the important question of providing easy control over each boiler and the individual furnaces. It will be noted from the drawing reproduced below that the burner valves and air-regulating handwheels are all grouped in a distinctive manner, and that each flame can be observed by means of the sight-hole doors provided in the boiler outer casings. Oil pressures and temperatures are registered at every boiler.

In addition to the observation doors at the furnaces, smoke observation doors are provided in each uptake limb. An arrangement of oblique mirrors, which, in effect, embody the principle of the periscope, enables the attendant on the floor-plate of the boiler room to observe at all times the nature of the smoke being generated. Pyrometers are fitted in each uptake by means of which the flue-gas temperature may be readily ascertained. "W.R." CO_2 recorders, as illustrated on page 242, indicate the proportion of CO_2 in the uptake gases. The oil is heated to a temperature of 220° F. to 240° F., according to the specific gravity, and is delivered to the burners at a pressure of about 75-100 lb. per sq. in., according to the power required. It will thus be seen that every factor essential for conditions of perfect combustion is constantly registered by instruments of precision, giving sensitive control. With due care and experience the best conditions are readily obtained, and 12 to 13 per cent. CO_2 with an uptake temperature of 450° F. to 500° F. are results which are frequently secured.



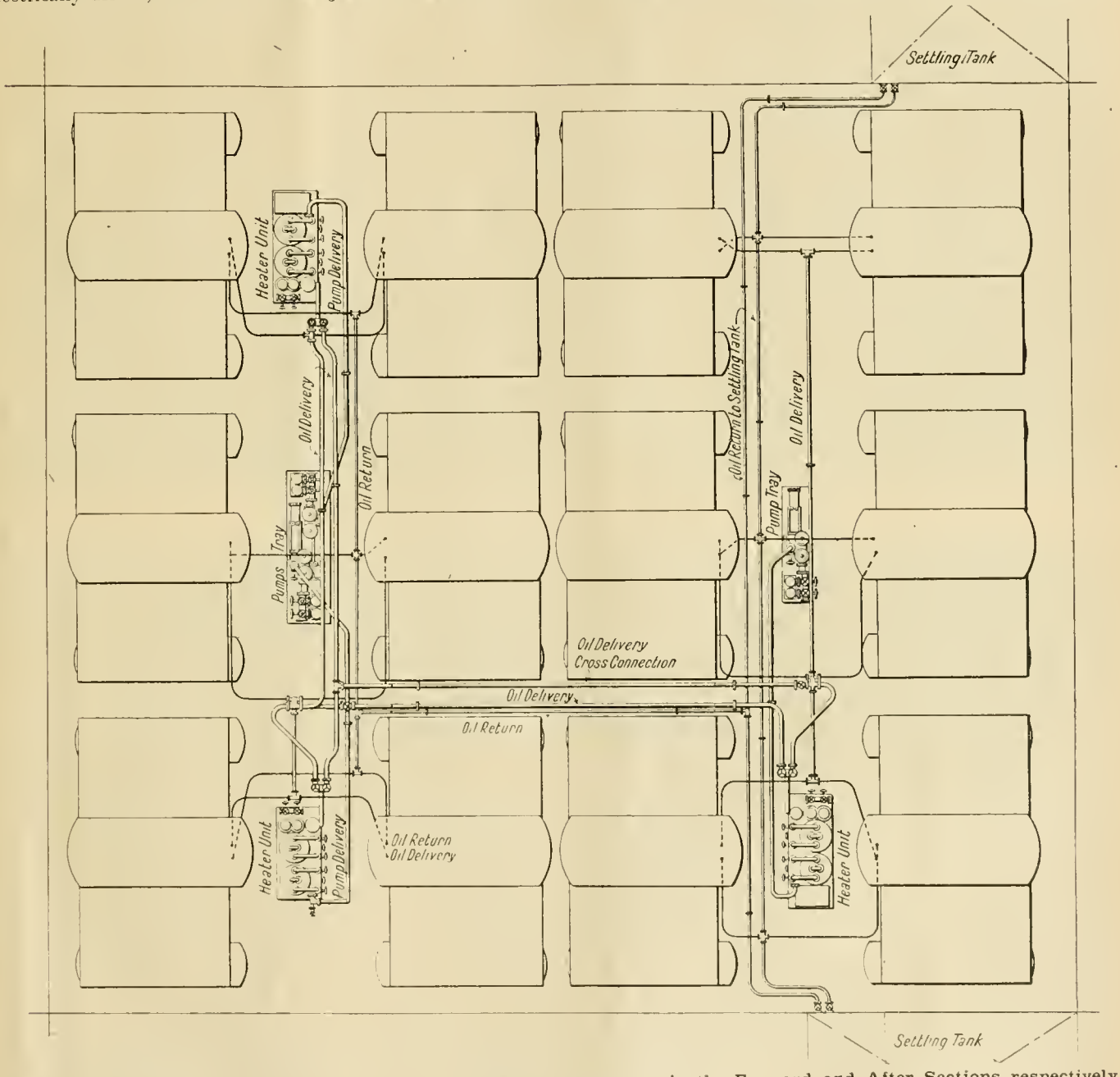
Arrangement of Furnace Fronts on the "Berengaria" showing Air Regulators and Fuel Admission and Return Leads.

Precautions against Fire.

The very grave consequences attending a fire on a passenger-carrying vessel of this size and the rapidity with which an oil-fire, once alight, spreads, are facts sufficiently obvious to call for no elaboration. All the heater and pumping sets in every boiler room have been very carefully protected by the erection of sheet-iron guards to prevent the possibility of oil from a leaky pressure joint, say, impinging on the hot boiler furnaces. A liberal supply of sand is provided in each boiler room against the possibility of minute outbreaks, and trays for the reception of this sand are provided under all furnace fronts, as shown in the photographs. Special ventilating ducts are led under the boiler room floor-plates, and these ducts are provided with exhaust fans at their upper end to extract any gas fumes which may accumulate due to the presence of oil on the tank tops. Hot salt water piping supplies each boiler room, and it is the duty of each watch

to maintain the tank tops in a state of immunity from oil. A large number of hand Foamite fire-extinguishing sets are disposed at convenient points in the several boiler rooms, and these, with the aid of sand, will be utilised to quell minor outbreaks of fire should such occur.

For a more serious outbreak of fire a large capacity Foamite installation has been provided. The tanks for the "A" and "B" solutions are arranged on "H" deck, and some indication of the capacity of this installation may be gathered from the photograph on page 244, showing one of the Foamite tanks. Unlike the Foamite pumps on the *Mauretania*, which were electrically driven, those on the *Berengaria* are steam driven, being generated in great volume. The effervescence or froth generated is stated to have a volume eight times that of the combined volumes of the original solutions. In each boiler room a fire-hose is mounted on a reel, carried on hollow trunnions through which the separate solutions are admitted by means of dual cocks, as shown. Mixing of the solutions does not take place until the hose reel is reached so that the effervescence, or fire-quenching virtue of the mixture, should not be lost by surface friction in extended lengths of piping, as would occur were the mixing effected at the pumps. These fire hoses are capable of reaching all parts of any boiler room or, if required, the adjacent boiler room. A steam sprayer



Plan showing Single and Duplicate Pump and Heater Arrangements in the Forward and After Sections respectively of No. 4 Boiler Room.

and are illustrated on page 243. In the event of a fire in any section, communication is immediately established with the engine room, and the pumps are started by means of extension rods from the engine-room platform to the pump steam stop and drain valves. The value of Foamite as a fire-extinguishing agent is dependent upon the effects of the chemical union of acid and alkaline solutions, which results in CO_2 or perforated pipe, is led through each boiler room, under the floor-plates, as an additional precaution. Extension-rods are carried from the tank suction valves, fuel pumps, &c., so that these may be controlled from the main deck.

General Reconditioning and Overhaul.

In addition to the structural work necessary in connection with the conversion to oil-burning as already described, a

considerable amount of reconditioning work was also carried out. No fewer than 45 of the water-tube boilers were re-tubed throughout, which necessitated cutting out more than 43,000 tubes and replacing them with the same number of new tubes. Each row of tubes varied in length and it was also found that variations occurred in the length of tubes in the same row. This involved the individual measuring, charting and identification of every tube, and in spite of the complex nature of this work an average of 6,500 tubes were installed each week. The new tubes were made by Tubes Limited, from steel manufactured by the Partington Steel and Iron Company. This work represents the largest boiler repair contract ever carried out on the Tyne, and when it is stated that the total weight and length of new tubes were 400 tons and 85 miles respectively, and that approximately 60,000 new fire-bricks were fitted, some idea of the magnitude of the task may be obtained. The large unsupported area of the upper steam-drums of the boilers was considered to be undesirable, and three longitudinal steel stays, $2\frac{3}{4}$ in. diam., were fitted to each steam drum in the form of an equilateral triangle surrounding the manhole door, and set with its apex inverted. The importance of an adequate supply of distilled water for boiler feed purposes will be manifest to all conversant with the operation of water-tube boilers, and the existing battery of evaporators has been supplemented by the addition of two large Caird & Rayner units. Each of these new evaporators is capable of distilling 100 tons of fresh water every 24 hours. As an additional precaution, special salt-water detectors have been fitted to the feed tanks. Two new calorifiers for the hot salt-water scouring system have also been embodied in this equipment.

Concurrently with the work of conversion already outlined, opportunity was taken to effect a complete renovation of the passenger accommodation. New rooms have been installed, old rooms have been extended, all accommodation has been completely overhauled and where necessary new furniture has been provided. A notable alteration is that effected in the lifeboat arrangements, resulting in the removal of a considerable amount of top weight. With the modified arrangement the promenade space has been substantially increased, and the external appearance of the vessel has been considerably enhanced. Some of the rooms in the *Berengaria* are among the largest and finest to be found in any vessel afloat, and this spaciousness obtains in a particularly noticeable degree in the state-rooms. Among the more outstanding features of the vessel may be mentioned the large swimming-bath, magnificent new ball-room, with its parquet floor, fully equipped gymnasium, luxurious palm court, garden verandah-cafe, tea-room, regal suites, numerous bath suites, &c.

Speed Characteristics.

With the very fine speed performances of the *Aquitania* and *Mauretania*, subsequent to their conversion from coal to oil-burning, and in view of the much more uniform conditions of steam production always associated with oil burning, there is every reason to anticipate that the *Berengaria's* previous best speed performance will be improved upon when the equipment has become fully adapted to service conditions. The vessel's previous best passage from Cherbourg to New York is stated to have been made in 5 days 22 hours 48 minutes.

We wish to place on record our indebtedness to the Cunard Company for the facilities placed at our disposal for photographing the installation in the *Berengaria*; to Mr. J. Austin, Superintending Engineer of the line, Mr. James McDonald, O.B.E., R.N.R., Chief Engineer of the *Berengaria*, and others for their kind assistance.

TWO TRIAL TRIPS IN ONE DAY.

A very interesting event occurred on May 2, when the North Eastern Marine Engineering Company Limited, of Wallsend-on-Tyne and Sunderland, carried out simultaneous sea trial trips off the River Tyne on two cargo vessels, each propelled by different types of machinery. One was from their works at Wallsend and the other from their Sunderland works.

The Wallsend vessel was the motor-ship *Segovia*, a sister ship to the *Sevilla*, which successfully completed her trials in November last year. The propelling machinery is of the North Eastern Werkspoor four-stroke type of Diesel engines of 1,400 h.p., manufactured under licence from the Werkspoor Company, Amsterdam, and an illustration and description of these engines appeared in our May issue.

The vessel was built by Wood, Skinner & Co., Bill Quay, Newcastle-on-Tyne, and is 270 ft. in length, with a beam of 37 ft. 8 in., the total deadweight carrying capacity being about 2,000 tons, and, as in the case of the sister ship *Sevilla*, was built to the order of the Otto Thoresens Line of Christiania.

On the same day from Sunderland the company carried out a trial trip on the ss. *Eirini Kyriakides*, which proved entirely satisfactory. Mr. N. G. Eyriakides, the owner from Athens, was present on the trial trip, with the Superintendent Engineer, Mr. E. C. Chaston, of Newcastle. The builders of the vessel, Robert Thompson & Sons, Southwick Yard, Sunderland, were represented by Mr. Harvey, and the North Eastern Marine Engineering Company Limited, by Mr. C. T. Adams, manager of their Sunderland Works. This vessel is 372 ft. in length, 50 ft. in breadth, and 25 ft. 5 in. moulded depth, and is fitted with triple-expansion engines, 25 in., 42 in. and 68 in. in diameter by 45 in. stroke, supplied with steam at 180 lb. per sq. in. pressure from two cylindrical boilers, 16 ft. 6 in. × 11 ft., giving a mean speed on the measured mile of 11 knots.

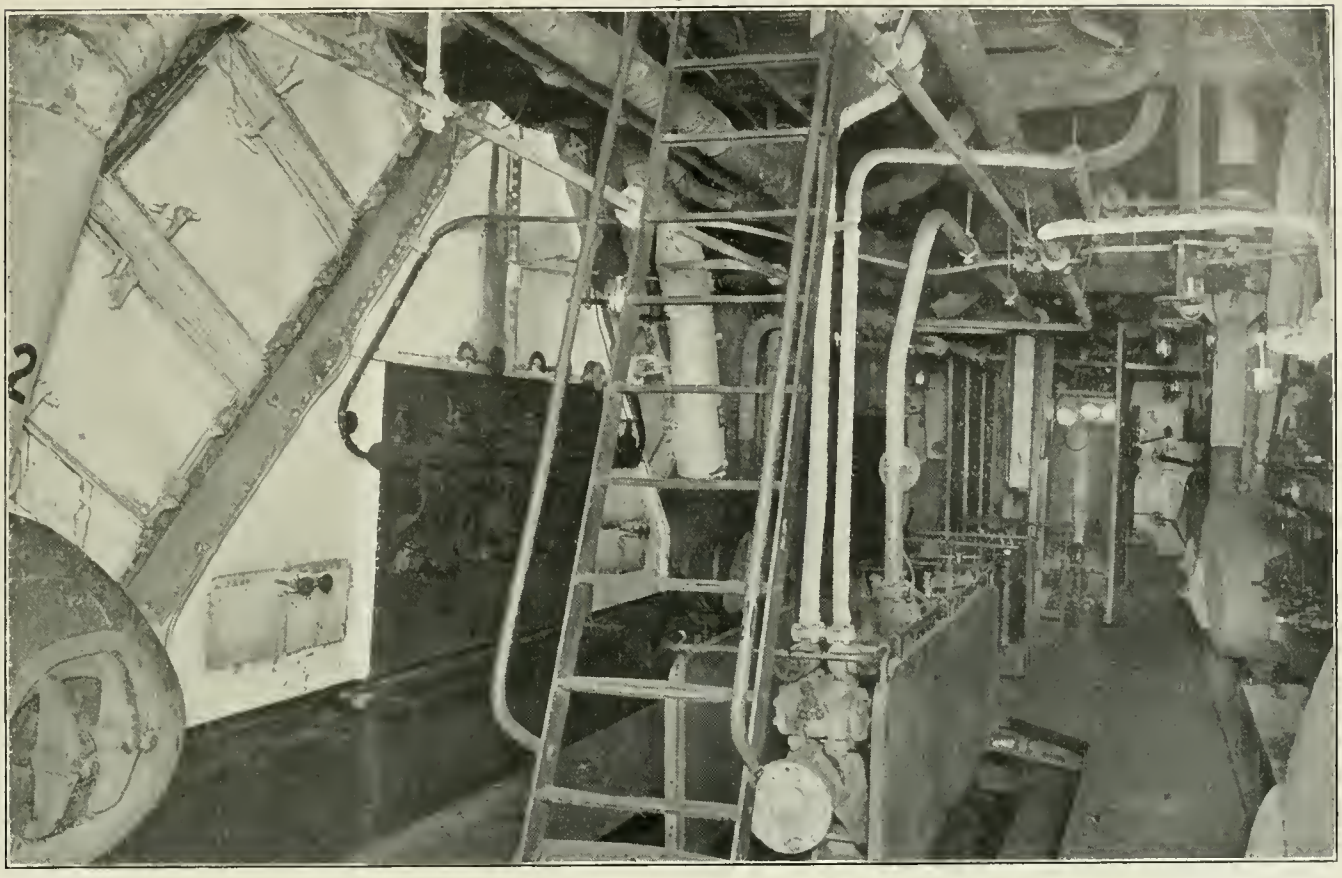
In these days of trade depression it is indeed unusual to learn of a company running two trials on the same day, and the North Eastern Marine Engineering Company Limited are to be congratulated on the successful completion of the machinery for vessels, bearing in mind that they were finished and the trial trips run, by apprentices and the firm's officials, owing to the engineering trade lock-out.

Wilson Plastic Arc Welding Process.—We understand from G. D. Peters & Co. Limited, that the Committee of Lloyd's Register has recognised the Wilson Plastic Arc Welding Process for use in repairs carried out on vessels classed in the Society's Register.

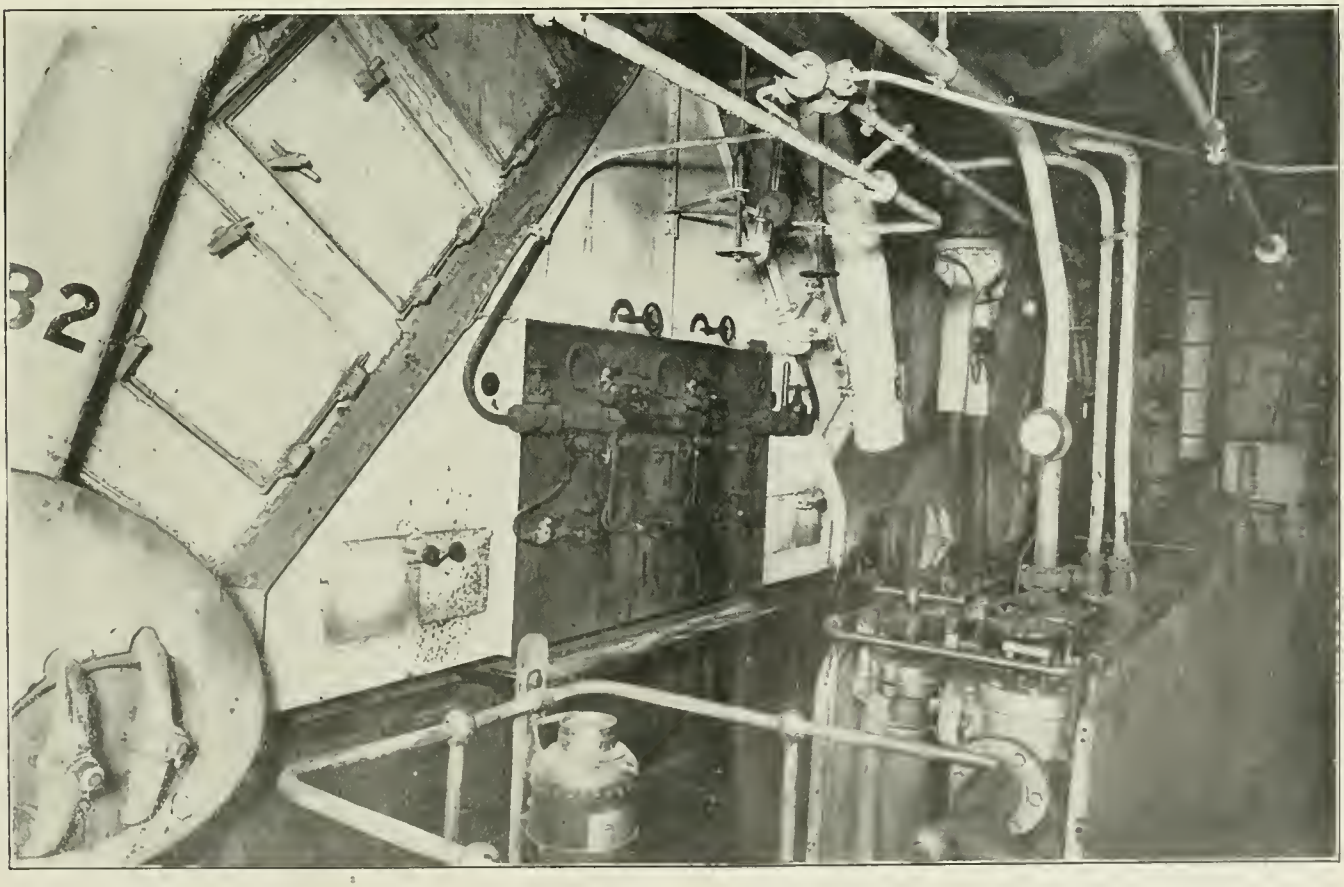
Austria's Great Iron Works.—The annual meeting of the Alpinen Mantan Company (Austria's greatest ironworks) was held at Vienna on May 2 under the presidency of Herr Hugo Stinnes. It was resolved to increase the capital from 100,000,000 to 200,000,000 crowns. A dividend of 50 per cent. was declared, but at the present price of the shares this dividend actually represents less than one-eighth of 1 per cent.

The Institute of Transport.—In connection with the London Congress of the Institute of Transport which was opened on Wednesday, May 17th, by the President, Sir Henry P. Maybury, K.C.M.G., C.B., a series of papers was read at the Institution of Civil Engineers and at the Royal Society of Arts respectively from May 17th to May 19th inclusive. Visits to places of interest in the city and in the dock area were carried out during the week, and on the evening of May 16th, the President held a reception at the Hotel Metropole. On Wednesday evening, May 17th, the Rt. Hon. the Lord Mayor of London entertained the Congress at a conversazione held in the Mansion House.

OIL-FUEL ARRANGEMENTS ON THE CUNARDER "BERENGARIA."



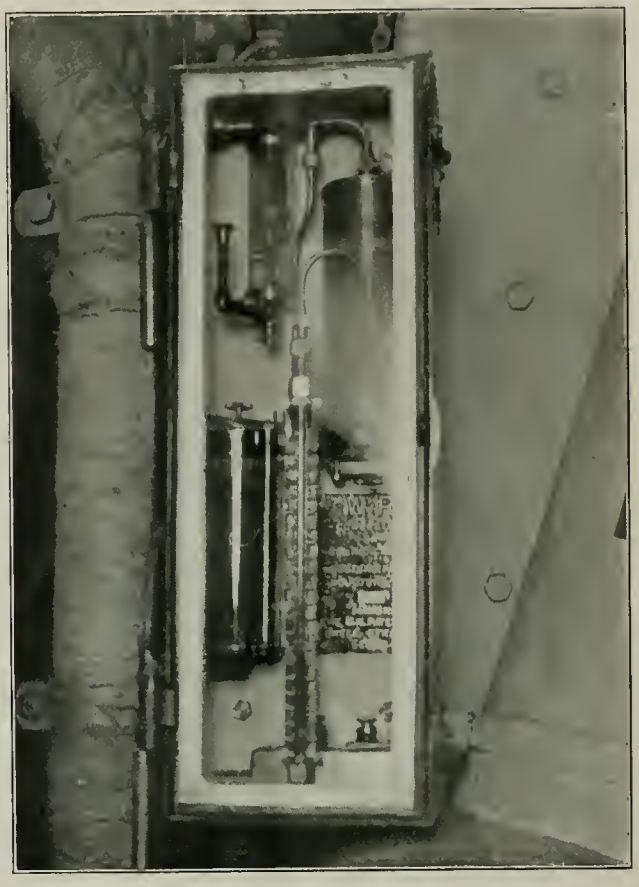
General view of Forward Section, No. 2 Boiler Room, looking to Starboard.



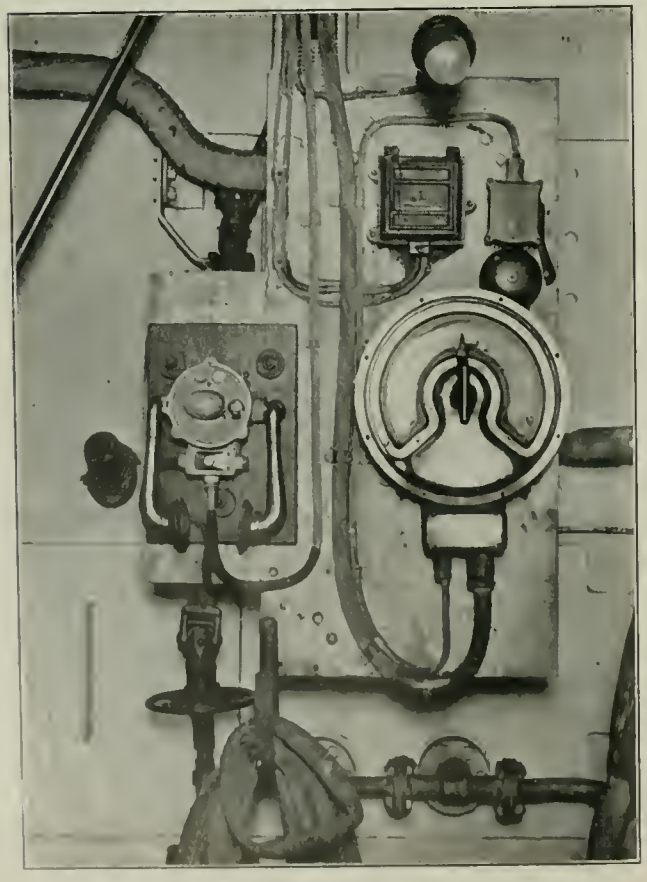
Forward Centre Boiler, No. 2 Boiler Room, showing "Downcomers." Weir's Unit Oil-Fuel Pumps may be seen in foreground.

OIL-FUEL ARRANGEMENTS ON THE CUNARDER "BERENGARIA."

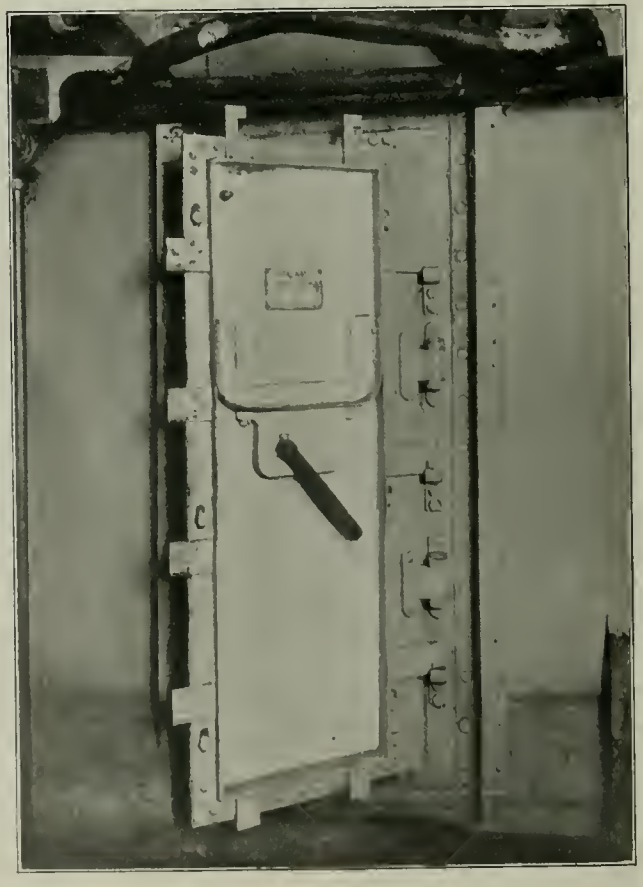
Mumford's Patent Automatic Feed-Water Regulator on Steam Drum. Note three additional longitudinal Drum Stays.



"W.R." CO_2 Recorder in Forward Section, No. 1 Boiler-room.

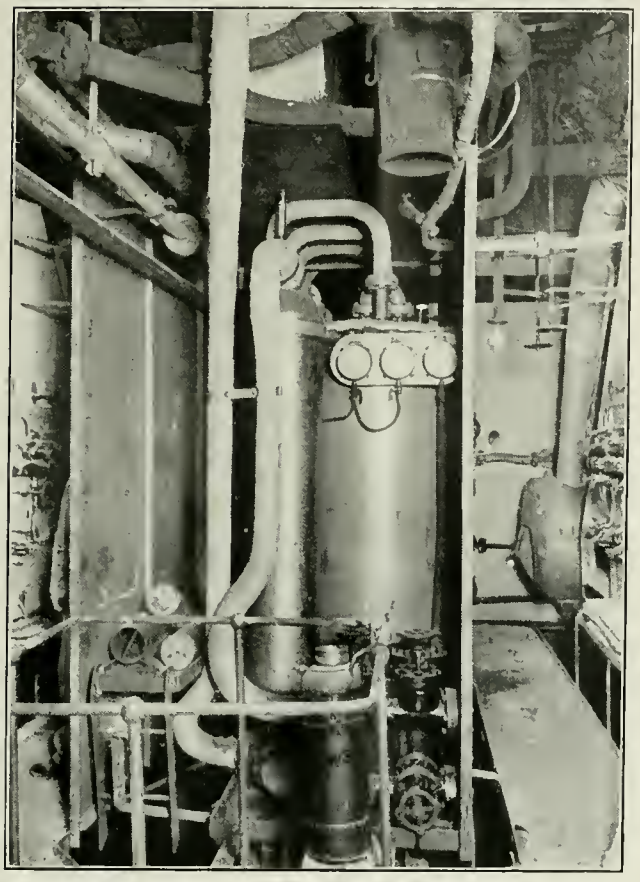


Graham's Patent Navy'phone and Stokehold Telegraph in after Section, No. 2 Boiler-room.

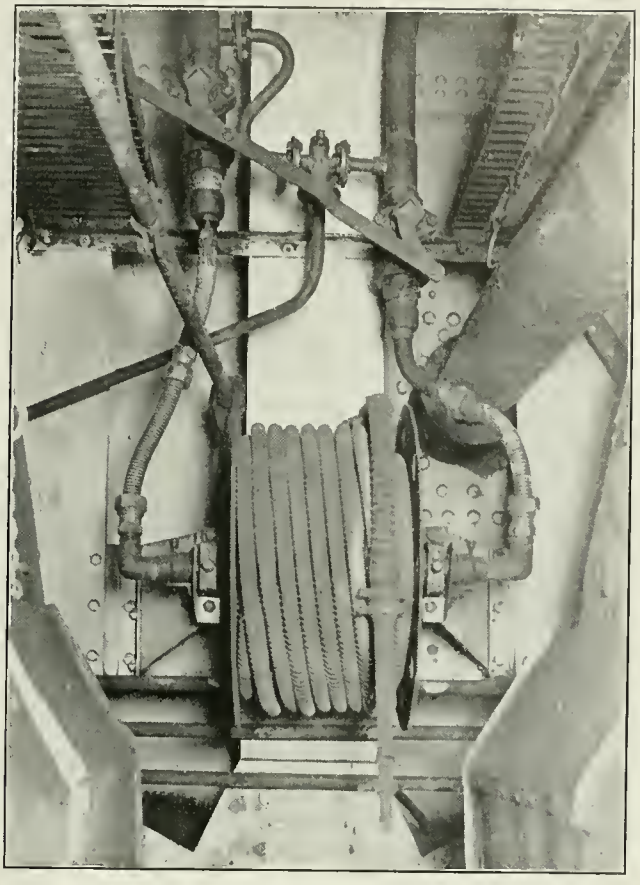


Stuart Patent Watertight Door leading from Engine-room to Foamite Pump-room on port side "H" Deck.

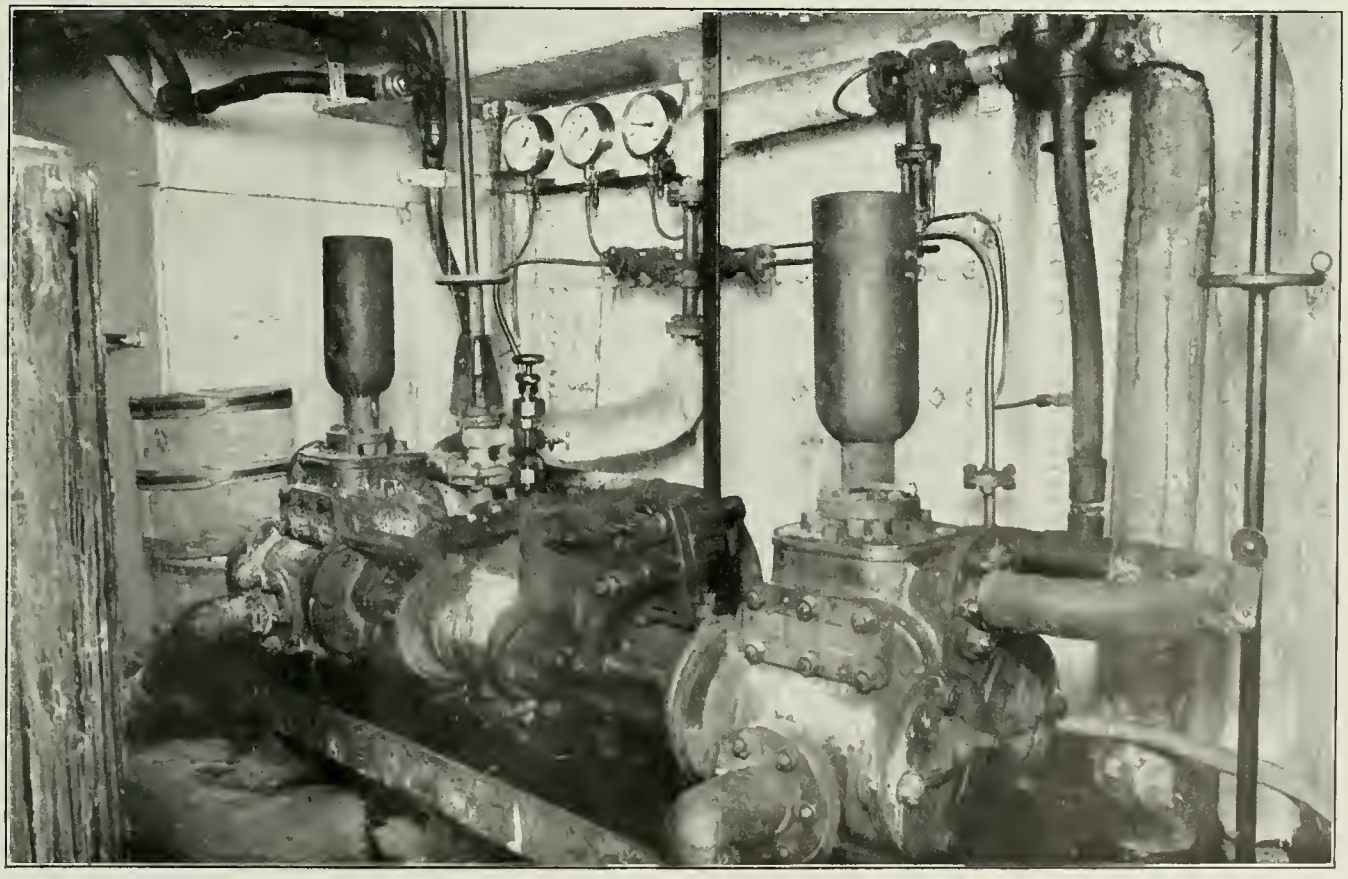
OIL-FUEL ARRANGEMENTS ON THE CUNARDER "BERENGARIA."



Forward Section, No. 3 Boiler-room, showing "White" Oil-fuel Heater.

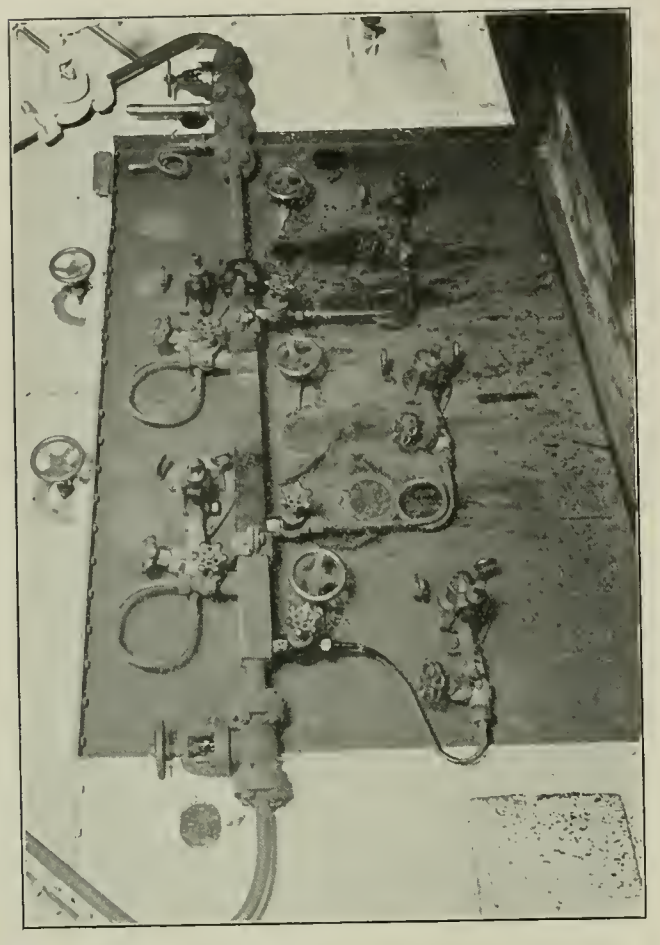


After Section, No. 1 Boiler-room, showing Foamite Fire-hose Reel and Dual Cocks.

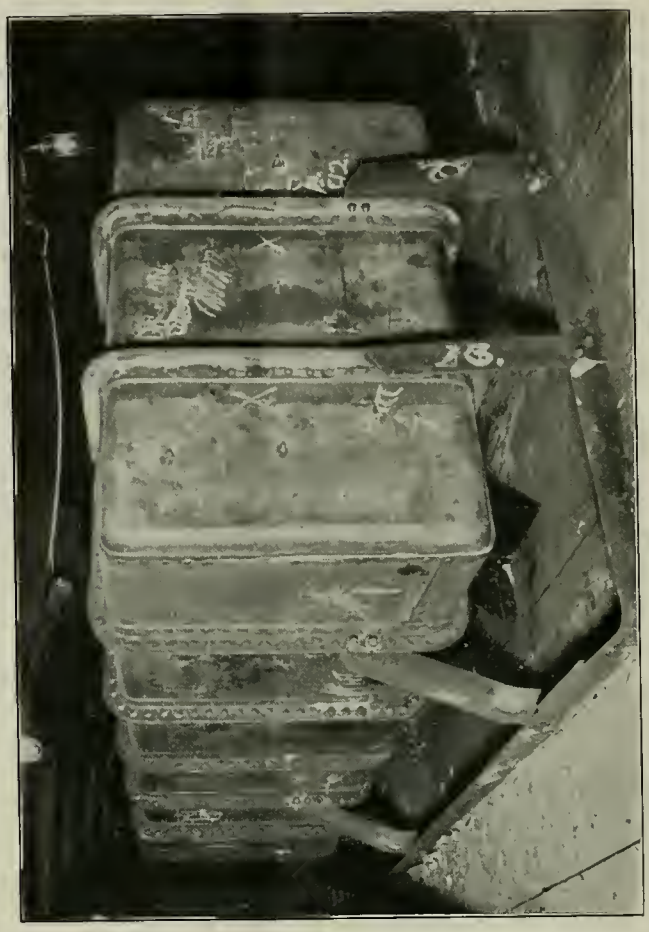


Steam-driven Foamite Pumps on "11" Deck, showing extension-rod from Stop-valve to Engine-room platform.

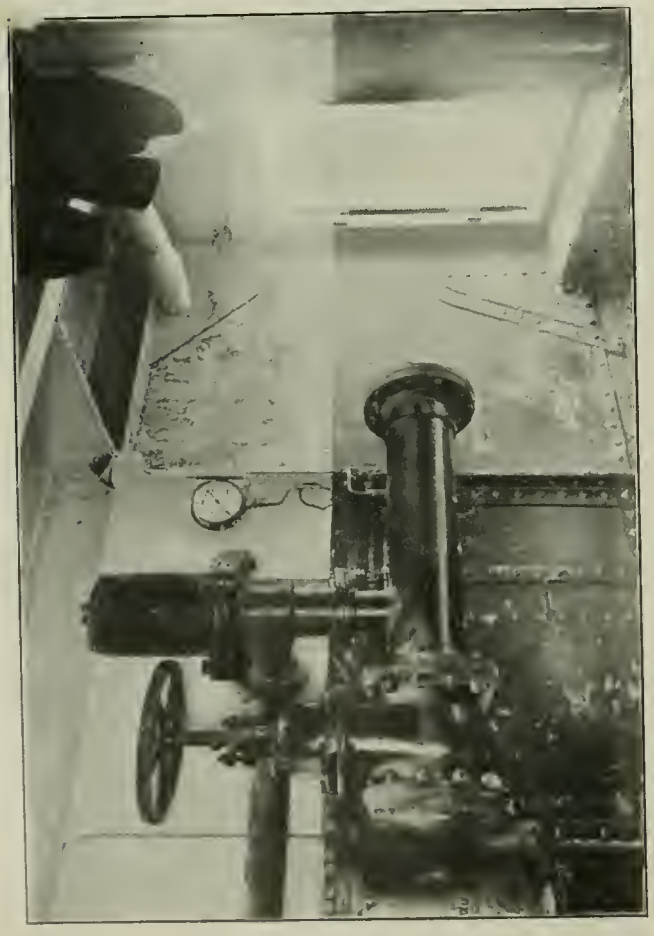
OIL FUEL ARRANGEMENTS ON THE CUNARDER "BERENGARIA."



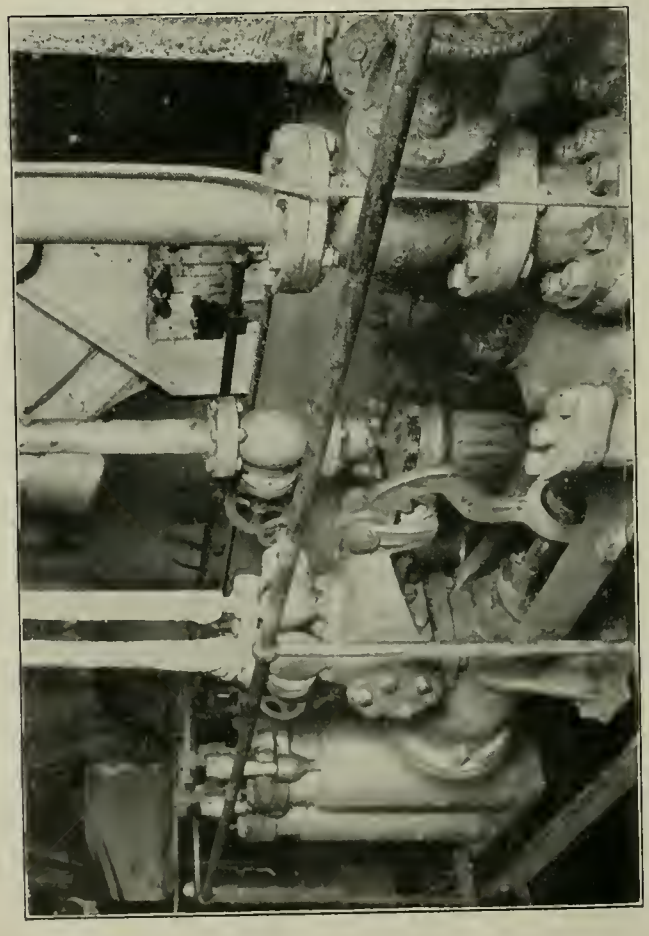
Furnace front arrangement, forward Centre Boiler, No. 2 Boiler Room, showing five Air Regulator Controls and "White" Burners.



Foamite Tank—25' × 6'-6" × 4'-0" in former reserve bunker space on "H" deck.



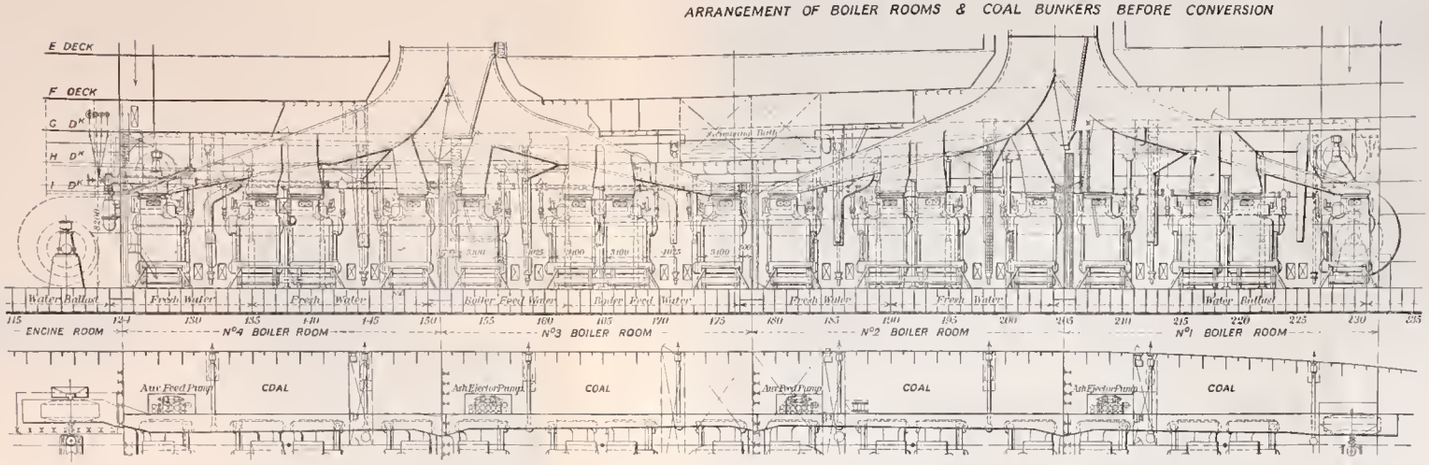
Starboard after Filling Station from Inboard, "G" deck, showing Filter, Sluice-valve and Excess Pressure Relief Pipe.

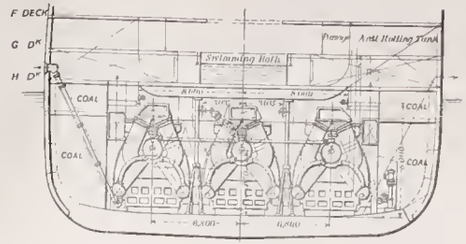


Weir's Oil-fuel Unit Pumps in duplicate, with Filters—after Section, No. 2 Boiler-room.

ORIGINAL COAL BUNKER ARRANGEMENTS AND EXISTING OIL-FUEL SYSTEM ON THE CUNARDER "BERENGARIA."

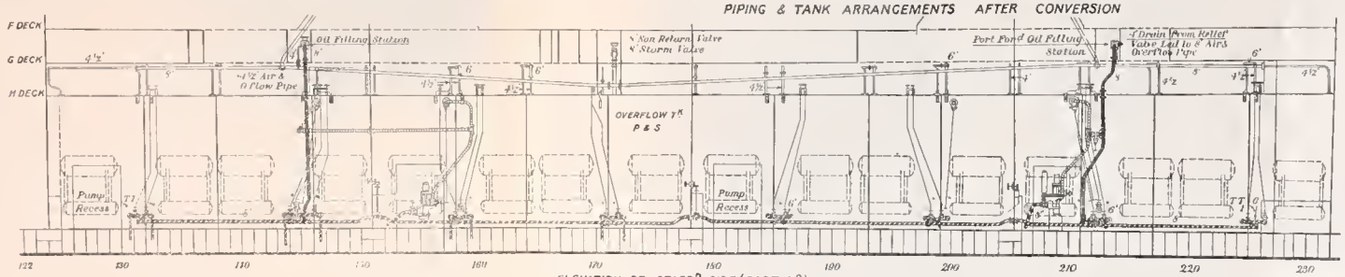
ARRANGEMENT OF BOILER ROOMS & COAL BUNKERS BEFORE CONVERSION



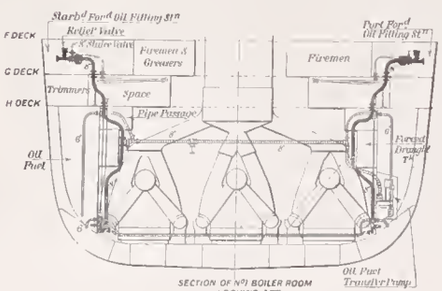


SECTION AT FRAME 178

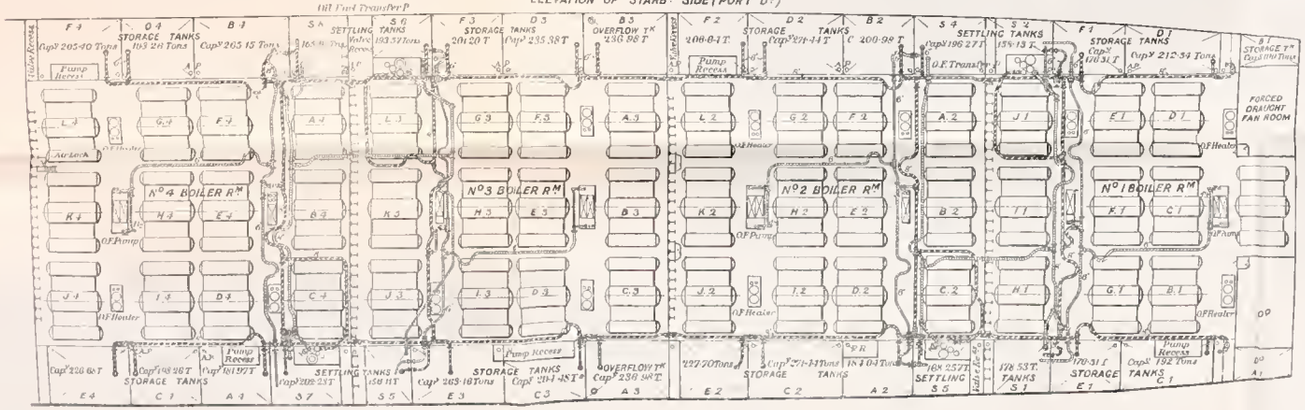
PIPING & TANK ARRANGEMENTS AFTER CONVERSION



ELEVATION OF STARBD SIDE (PORT DO)

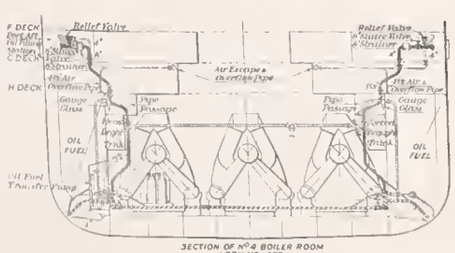


SECTION OF N°1 BOILER ROOM LOOKING AFT

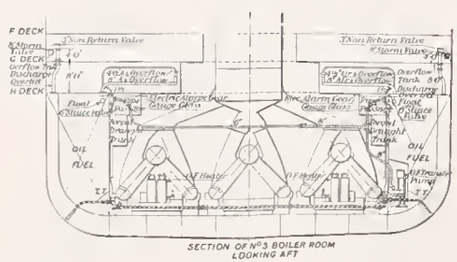


PIPE SYSTEM

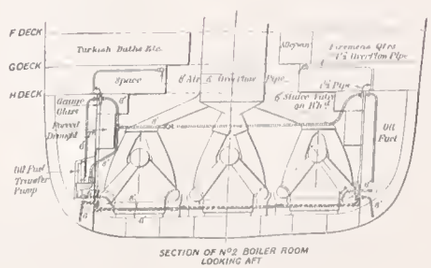
Oil Fuel Filling Main
Oil Fuel Transfer Pump Suct.
Air Pipes Etc.
Oil Fuel Bulk Sections
Oil Fuel Transfer Discharges



SECTION OF N°4 BOILER ROOM LOOKING AFT



SECTION OF N°3 BOILER ROOM LOOKING AFT

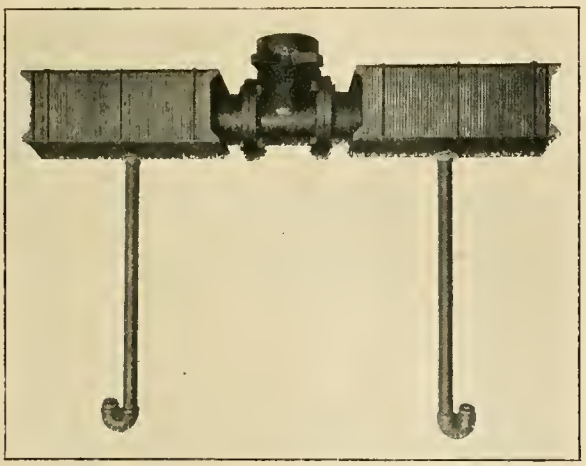


SECTION OF N°2 BOILER ROOM LOOKING AFT

SUPERHEATERS AND DRY STEAM.

The Tracy Steam Purifier—Effect of Superheat on Fuel Consumption—The Elimination of the Effects of Priming.

The presence of water in steam after it leaves the boiler, owing to priming and to impurities in the water, besides increasing the steam consumption—and fuel consumption—has deleterious effects on the engines. In the case of reciprocating engines it is liable to cause damage to the valves, piston rings and rod packings. In turbines it sets up erosion of the blades, thus involving costly repairs. It is therefore greatly to be desired that every step should be taken to eliminate the presence of this moisture. As a means to attain this, superheaters are used, the moisture is evaporated and superheat added. Superheated steam has a greater volume and contains more heat units per pound than wet steam, and therefore does more work, thus giving greater efficiency. The fuel economy, by superheating the steam, varies with the conditions, but is claimed to be from 5 to 15 per cent. As the temperature is increased, greater fuel economy is gained. Steam superheated to a high degree introduces



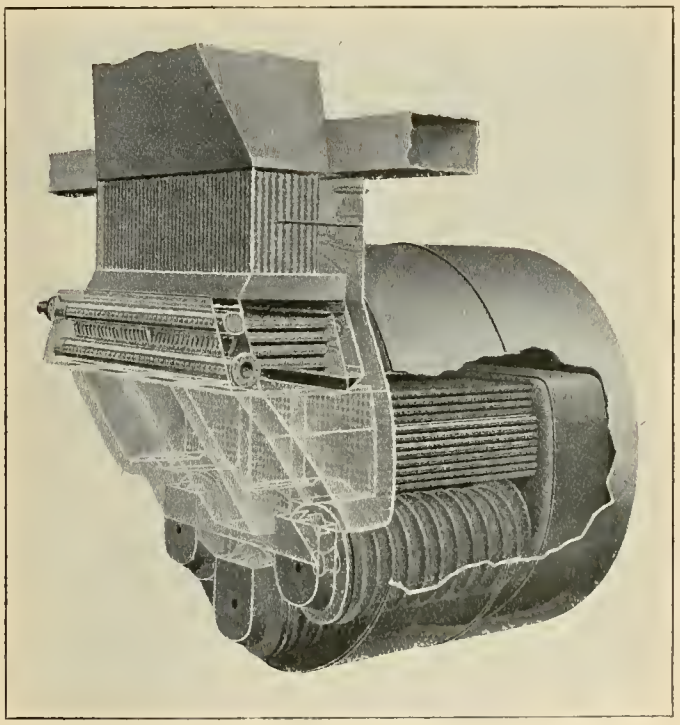
Tracy Steam Purifier with Centre Outlet.

lubrication difficulties and additional wear and tear with correspondingly high upkeep costs, but these disadvantages are eliminated by the use of moderately superheated steam. Superheat will also reduce the condensation of steam in pipe lines, although a certain amount of condensation will always take place in extended lengths of piping.

It has been found that a superheater capable of giving 100° Fahr. of superheat when supplied with dry steam at 200 lb. gauge pressure will have its superheat reduced about 14° Fahr. for each per cent. of moisture in the entering steam, which percentage, on reaching 7, would entirely eliminate the superheat.

The reduction in superheat due to the wetness of the steam would cause an increase in the steam consumption of the engines of about 1 per cent. for each 10 per cent. reduction in superheat.

To overcome this difficulty a larger superheater surface could be installed, but a more economical method of dealing with the matter seems to be to install purifiers and supply dry steam to the superheater. In addition to the moisture in the steam there is also the question of impurities, which, deposited on the superheater tubes, impair their efficiency, or, if they pass through the superheater to the machinery, will have deleterious effects. By the installation of a purifier this latter defect would also be efficiently dealt with. We recently paid a visit to the *Plum Branch*, a geared turbine steamer of 4,798 tons gross owned by the Nautilus Steam Shipping Company Limited (F. & W. Ritson, managers), built and engined by Palmers Steel and Iron Company Limited, Newcastle. This vessel was fitted with the Foster waste-heat type superheater, which is illustrated below. This type of superheater is placed in the uptakes above the smoke box, and its function is to absorb heat from the gases on their passage to the funnel, and communicate such heat to the steam. The boilers were also fitted with Tracy steam purifiers, shown opposite. The *Plum Branch* had just completed her maiden voyage and had been away from this country for about five months, sailing chiefly round the South American Coast.



Scotch Marine Boiler fitted with Foster Superheater and Howden Tubes in the Uptake.

Fairly good quality South Durham coal had been burnt for practically the whole of the voyage. The chief engineer stated that throughout the whole voyage the superheater had given entire satisfaction. No difficulty was experienced in keeping it clean; the desired temperature was consistently maintained throughout; in fact, they had not given him a moment's trouble or concern since first leaving this country. The average total temperature at the superheater outlet was from 480° to 500° Fahr. This works out at a superheat temperature of 100° to 120° Fahr. and resulting in a net fuel economy of 12 to 15 per cent., which can be considered as highly satisfactory. It is noteworthy that in obtaining this superheat of 120° Fahr. with coal-fired boilers, the uptake temperature immediately below the superheater was less than 625° Fahr.

The chief engineer was equally pleased with the performance of his purifiers. After about two-fifths of the vessel's total run had been completed he had the purifiers cleaned and the

(*Continued on page* 252.)

A NEW CHAIN-GRATE STOKER.

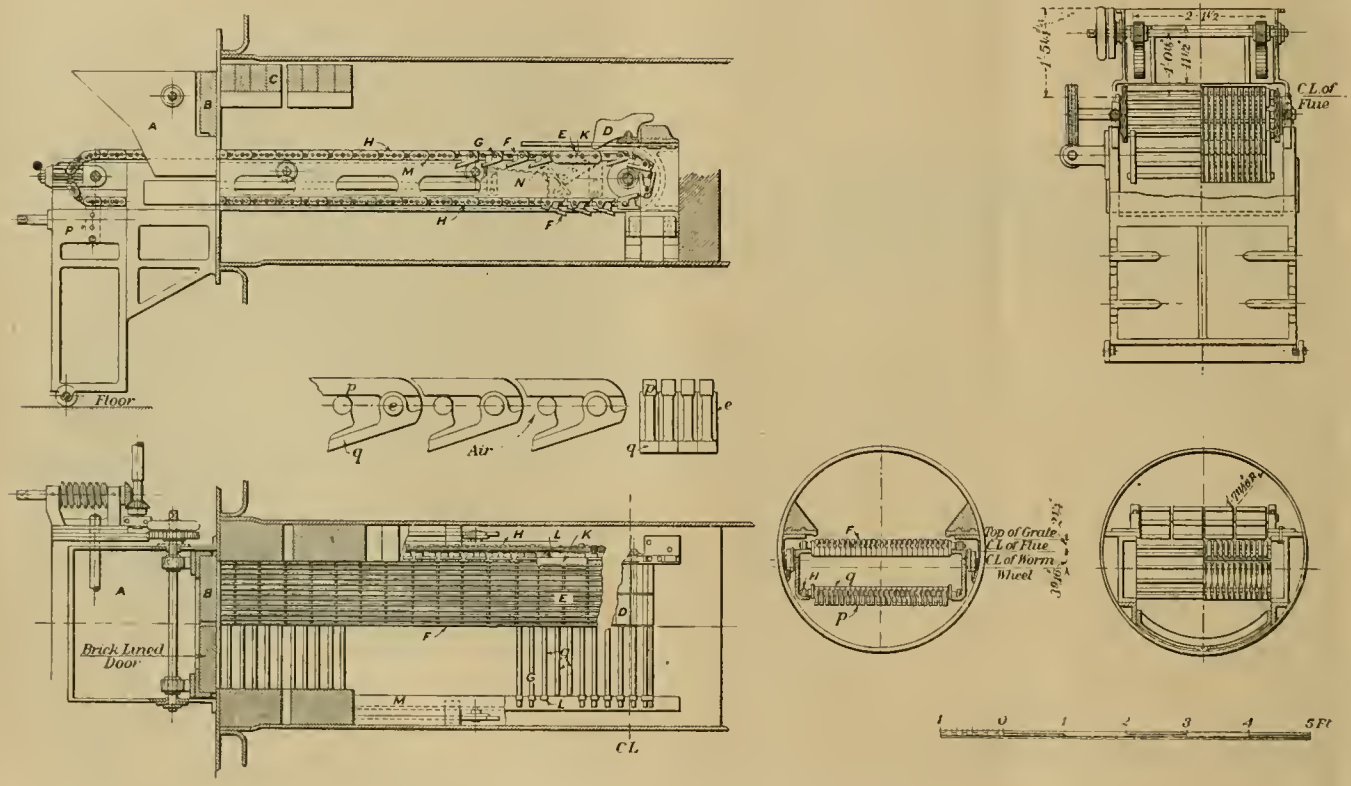
Mechanical Method of Coal Firing—Self-cleaning Features—Application of Chain-grate to Marine Boilers.

Although many steamers have been, or are being, converted from coal-burning to oil-burning vessels, the demand for coal for the generation of power on land increases year by year, nor are we within sight of the time when it will be rivalled by any of its competitors.

This being so, any improvement in the methods by which coal can be fed to a boiler furnace cannot fail to be of interest to engineers in general, and a recent patent in connection with a mechanical stoker, on the well-known chain grate principle, embodies in at least one respect what appears to be a distinct advance on anything now on the market. This feature is its self-cleaning arrangement.

In nearly all existing mechanical stokers, even when the to accumulate in a small pile, across the entire width of the grate.

At intervals, which may be varied to suit the nature of the fuel, a section of the upper run of the grate (which is travelling inwards) falls open immediately under the accumulation of ash, causing the latter to be deposited on the lower run of the grate (which is travelling outwards), and in this manner the ashes are carried to the front of the boiler. On their arrival at the front, a section of the lower run falls open, and the ashes are discharged outwith the boiler furnace. Immediately after any section of the grate opens, it automatically re-closes, so forming a continuous moving grate, except at the positions and times referred to above.



Details of New Self-cleaning Chain-grate Stoker.

phrase "self-cleaning" is assumed by their makers, the ash and clinker have to be removed from the furnace or ash-pit by the attendant, but in the case under notice, the stoker does actually bring the ashes from the rear of the furnace and deposit them on the floor in front of the boiler. Not only are the ashes not touched by hand, but the fireman does not require to set any mechanism in motion; the machine itself discharges the ashes without attention, at longer or shorter intervals as may be desired.

The coal is first fed into a hopper at the front of the boiler. Beneath the hopper is a travelling grate which carries the coal into the furnace, the thickness of the layer of fuel being regulated by a sliding door—all as may be seen in some of the best-known stokers of this type. When, however, the fuel has become thoroughly burnt, and has reached the rear of the furnace, instead of being carried over the back of the grate, it is arrested by heavy scrapers which cause it

Another feature of the stoker is the grate-bars or links which form the moving bed. When these are on the upper run ample air-spaces are provided for the proper combustion of the fuel, but on the lower run they automatically fall over on the rods on which they are strung, becoming a close and continuous moving band, which effectually prevents the ashes from dropping through while in transit to the front of the furnace.

In some of the better known stokers with moving grates the accumulated ashes are cleared from the rear of the furnace at intervals by means of a lever in the side wall of the boiler. This method is, of course, not applicable to shell boilers of the ordinary Lancashire or Scotch marine types, but this difficulty does not arise in the case of this self-cleaning stoker, which has been specially designed for such boilers.

The whole machine is carried on small wheels, running on

rails, which enable it to be conveniently withdrawn from the furnace for examination or repairs.

The drawings on opposite page will assist in making clear the action of the apparatus :—

A is the hopper which in practice would usually be filled by a chute from an overhead bunker.

B is the guillotine door for regulating the thickness of the bed of fuel.

C is a firebrick arch.

D are the C.I. scrapers against which the ashes accumulate as the grate moves inwards.

E are the hinged sections, or falling " grates."

It will be observed that the grate-bars " F " have a hole at one end by which they are strung on every second rod " G " ; the other end is supported by the alternate rods which pass through the gap at that end of the links. The bars " F " swing freely on their eyes to the extent allowed by the gap. All the rods " G " pass across the full width of the grate and through the links of the side chains " H."

At such intervals in the chain grate as the quantity of ash produced requires, are introduced the gates "E." As will be seen from the drawing, one rod (the hinge rod) passes through the side chains " H " but the other three (marked " g ") are shortened. Two of them have their ends flush with the outer edges of the bars " K " which form the sides of the " gates." The third projects through the bar " K " and is fitted with a small ferrule or roller " L " on each end but does not enter the side chains " H."

These rollers " L " travel on guides " M " cast on the main frames and thus maintain the " gates " in the horizontal position as part of the grate. When, however, the rollers reach the point " N " where the guides are bent downwards, the rollers, following the path of the guides, allow the gate to fall as indicated by the dotted lines. This falling motion may be gradual or sudden according to the angle of the guides at " N." The accumulated ashes are thus deposited on to the lower run of the grate and are carried to the front of the furnace where a small action takes place, the " gate " falling to the position " P " and discharging the ashes on to the boiler house floor.

As already mentioned, the grate-bars " F " allow an ample supply of air to pass through when on the upper run. This is effected by having the arm " p " of a less width than the eye " e " ; the air entering freely as indicated by the arrows. The other arm " q " is of the same width as the eye so that the bottom run is a continuous band without openings. The accompanying sketches will make this clear.

A short trial has already been made in a Scotch marine boiler under forced-draught conditions, when the results were considered encouraging.

THE COMMONWEALTH GOVERNMENT ENGINE SHOPS.

Some Features of the Government Dockyard Equipment at Newcastle, N.S.W., Australia.

To those among us who are familiar with the excellent fighting qualities manifested by our Australian soldiers during the late war, it will come as no surprise to find that our distant colony is no less skilled in the arts and crafts of peace. The Government Dockyard Works at Newcastle, N.S.W., are of quite recent date, and to have developed from a site which was barren in 1913 to what is now Australia's premier shipbuilding and engineering establishment, occupying a total area of 140 acres, may be regarded as a distinctly meritorious achievement. Newcastle—like its older namesake on the Tyne—is very favourably situated in respect to coalfields, as it occupies a central position in Australia's greatest coalfield. The shipbuilding yard and the works are situated on a foundation of land reclaimed from the bed of the Hunter River.

We are not immediately concerned with the shipbuilding section of the equipment, but suffice it to say that the dockyard is planned on the unit system. The first unit, now completely installed and equipped, has a shipbuilding capacity of 20,000 tons per annum, and a building programme comprising six vessels, aggregating 35,394 tons d.w., has recently been completed to the order of the Commonwealth Government. A fine system of wharves has been laid out, equipped with numerous cranes and every facility for expeditious loading and despatch. Engines, boilers, deck auxiliaries, &c., are placed on board vessels at the fitting-out berth by means of a special high gantry crane.

The engineering shops comprise the pattern shop, foundry, machine shop, fitting shop, boiler shop, blacksmiths' shop, plumbers', coppersmiths' bolt and rivet shops, &c., and some idea of the lay-out and extent of these shops may be had from the series of photographs which we publish with this issue. Castings up to 40 tons in cast-iron and 8 tons in steel can be made at the foundry, and special facilities are also available for the production of any cast alloy that may be required. The machine shop is extensively equipped with the most modern tools, which ensure a high degree of accuracy in the finished work. These machines are arranged to cover a wide range of requirements, and principal among these are a face-plate lathe, capable of turning material up to 20 ft. in diameter; a large vertical planing machine, with a capacity to machine castings up to 14 ft. long × 12 ft. high ; and also several horizontal planers. A special double-ended lathe is available for work of unusual length, such as propeller shafts, &c., and this lathe can take work up to 46 ft. in length. Electrically-driven overhead cranes, with a capacity up to 50 tons, serve these shops. Gear cutting, straight and bevelled, is also undertaken by the dockyard.

Worthy of mention among the several sections of the boiler shop equipment are a 100-ton flanging press, heavy plate bending press, pneumatic and hydraulic riveters, &c., and the equipment as a whole is capable of meeting the highest requirements. A 3-ton forge is installed in the smithy, and steel shafting up to 7 and 8 tons weight has been forged entirely from Australian ore, and conforming in every respect to Lloyd's requirements. The bolt shop is capable of a large output of bolts, nuts, rivets, &c. Cast-iron and steel piping manufacture is carried out on a large scale. Iron pipes 6 in. in diameter are cast vertically in lengths of 12 ft. Apart from ship requirements, the dockyard has constructed steel pipes 36 in. in diameter for the 50-miles pipe line in connection with the Chichester water supply. This contract comprised a total weight of piping of 16,000 tons. The joiners' shop is capable of completely furnishing any type of vessel, including such work as the highest class saloon and cabin furnishings, chairs, tables, &c. A separate section has also been equipped for the building of ships' lifeboats.

Ship repair work constitutes an important branch of the dockyard's activities, and for this purpose a special repair shop has been provided in addition to the resources of the main works as already described. Two repair slips capable of accommodating smaller vessels of 400-900 tons displacement are available. Experienced shipbuilders familiar with the yards and shops in this country and in America have commented favourably on the equipment and lay-out of the dockyard establishment at Newcastle.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Evaporators.

Evaporators, as a detached auxiliary, have long been used for the supplementing of boiler feed water. Their weight, and the occasional nature of their use, have led designers to consider the possibility of lighter and more automatic units which could utilise the waste heat of the main machinery and require but little attention. Two main sources of waste heat are available, the flue gases and the auxiliary condenser circulating water. An apparatus making use of the flue-gas heat was fitted in the ss. *Steiermarck*. In this apparatus the circulating water from the wash-deck service system serves as feed water for the evaporator, and is delivered to a small condenser placed in the funnel casing. This condenser is directly connected to the main condenser, thus obtaining a vacuum of 85 per cent. The circulating water next passes through a container at the base of the funnel uptake, up a long nest of heating tubes in the uptake proper and thence to the evaporator. To the head of the evaporator a further nest of heating tubes is attached, and through these, the now evaporated portion of the circulating water passes on to the special condenser and thence to the hot well. The non-evaporated portion of the circulating water returns to the lower container. This installation behaved quite satisfactorily, but, because of its weight and difficulty of access, it is hardly to be recommended. The other method using the circulating water from the auxiliary condenser, was adopted in the ss. *Kaiserin Auguste Victoria*. The auxiliary condenser serves as a feed heater for the evaporator. The circulating water passes on to the evaporator where it impinges on to a baffle plate and the non-evaporated portion returns to the auxiliary pump. As the evaporator is directly connected to the main condenser, a vacuum of 95 per cent. is thus produced, and evaporation takes place at a temperature of 45° C., the evaporated steam passing on to the main condenser. This apparatus worked quite satisfactorily and produced 40 tons per day. The general question of evaporators is then considered and the difficulty of their cleaning contrasted with the obtaining of fresh water from ashore. Finally, the utilisation of winch steam is considered and a case quoted where with main machinery of 3,000 h.p. in one day's harbour work 50 tons of feed water were produced, *i.e.*, sufficient for eight days' supplementary main feed water.—*B. Bleicken, Werft, Reederei, Hafen*, March 22, 1922, p. 159; 2½ pp.; 2 ff.

Economical Construction of Barges.

To reduce the costs of hull construction two methods are open: first, to simplify and unify the construction of the hull, and second to improve the lay-out and building methods of the shipyard. In Germany the largest builders of small river craft are now the Gütehoffnungshütte Company, at Walsum, and their up-to-date methods of production are worthy of review. This firm has been in existence for 93 years and has been lately reconstructed. The new yard at Walsum is really the fabricating and building yard for the material which is prepared at the firm's well-known bridge building yard at Sterkrade. Standard barges have been designed to carry 1,350 and 1,700 tons and their construction simplified by use of the straight lined form which was developed in the Hamburg tank. The resistance of this type of barge has been shown, both by trial and model experiment to be 10 per cent. less than the usual conventional form. Full details of the structural design of these barges are given in this article. Another feature of these barges is that they are fitted with the Flettner patent rudder. This rudder consists of the ordinary balanced type with an auxiliary flap rudder attached to its after edge. By this device it has been shown from trials that only 5 per cent. of the power of the usual steering engine is necessary. Next the building yard is described. It is a 15 berth yard, the berths being parallel to the water front. The vessels, when ready for launching, are moved laterally from the building berth on to a slipway. Here they are placed upon a massive slip wagon which is electrically controlled and are then launched in the usual slipway fashion. Vessels to be repaired can be hauled up the slipway and be placed on any of the building berths. The production is controlled to turn out at least one barge per week. The shipyard machinery is electrically driven, although pneumatic work is extensively adopted. Electrical welding is used whenever possible for all detail work and for caulking shell seams. The building berth has twin gantries running the full length of the yard, and on these run four cantilever cranes for hoisting, erecting, and transporting purposes. The yard is certainly up-to-date in all respects. Many interesting photographs are given of the yard and its machinery and the barges built.—*Dr. E. Foerster, Werft, Reederei, Hafen*, April 22, 1922; p. 288; 6 pp.; 14 ff.

International Standardisation in Industry.

This article forms a very complete treatment on the function of standardisation in the economical development of industry. The first portion deals with the growth of local, and then national standardisation, and the various distinct organisations already in existence are analysed from a functional point of view. The second portion gives an impartial review of the possibilities and desirability of international standardisation, and reference is made to an unofficial conference that was held in London in 1920, at which the secretaries of the British, American, Canadian, Belgian, Dutch, Norwegian and Swiss standard associations were present. This conference facilitated the exchange of standard productions and showed, to a certain extent, that international standardisation was desirable. This was especially so in the matter of research work, the expense of which makes it imperative to avoid duplication. Finally, the subject is envisaged with special reference to shipbuilding. Little can be done towards the standardising of ships as such, but much can be done towards the standardisation of their component structural members and fittings. The standardisation and unification of the requirements of classification societies is approaching an international nature although much further liaison needs to be effected. The desire for international standardisation is especially felt from the point of view of facilitating repair work, and this will prove the greatest spur in its ultimate formation. Although many inborn prejudices are associated with the shipbuilding industry, the author hopes that his account of what has been done unofficially in other industries will contribute to some extent towards international standardisation in shipbuilding.—*E. Hijmans, Werft, Reederei, Hafen*, April 22, 1922; p. 253; 9 pp.; 5 ff.

The "Cumberland" Device for Minimising Corrosion.

The T.S.S. *France*, of the Compagnie Générale Transatlantique has recently had 19 of the boilers and her two main condensers fitted with the "Cumberland" electrical device for minimising corrosion. It is generally admitted that corrosion is the result of electrochemical action brought about between different metals, or between different portions of the same metal, when these are immersed in some form of electrolyte. The resulting current causes the positive electrode forming this voltaic couple to waste away. The usual method of providing against this effect in boilers is to fit zinc plates inside the boiler, but only a very limited protection is thereby assured unless the zinc is frequently renewed. This is due to corroded zinc being actually electro-negative to steel, Muntz-metal, and even to uncorroded zinc itself. The action of the "Cumberland" device is different: it consists in artificially producing in the electrolyte a counter current at a higher potential than the local voltaic couples, thus neutralising the tendency to corrode. Simultaneously the formation of the hydrogen film on the metal to be protected, tends to prevent any encrustation taking place thereon. The device consists essentially of two insulated iron anodes which are placed inside the boiler and which are connected to the positive pole of a generator. Each anode is provided with an independent resistance to control the current. The surface to be protected is connected to the negative pole of the generator, which is generally a rotatory transformer fed from the electric light circuit. The circuit is hence as follows, positive pole-anodes, water or electrolyte negative pole surface to be protected. On the *France* three rotatory transformers are fitted, two of which are in use and the third, auxiliary. The vessel's main circuit current is used and stepped down to a voltage of 10 volts. This low tension current is delivered to a main switchboard whence it is directed to

the particular boilers. A sketch is given showing the lay-out of the installations. Similar installations have been fitted in the *Aquitania, Berengaria, Mauretania* and *Majestic.*—*Bull. T.d.B. Veritas,* April, 1922; p. 97; 1 pp.; 1 ff.

Tests on Curved Beams.

The distribution of stress in U-shaped members of a machine has always been a matter for conjecture, and this article gives the results of an exhaustive research into the stress distribution of such beams made of cast-iron having a range of form of cross section such as is usually met with in practice. The testing machine used and the theoretical analysis adopted are described and the following observations are made on the basis of 63 detailed tests. The distribution of stress over the critical section up to the breaking point, due to tension, was practically a symmetrical hyperbola. The breaking stress was the same as that of simple tension test pieces cut from the same material. The assumption usually made in the theoretical treatment of this problem, that the cross section of the critical section remains plane after bending was found to hold good. Whether a test beam were machined or left in the rough did not perceptibly influence its strength. The strength increased with increasing radius of curvature and in a different manner for each type of cross section, depending upon the distribution of material at the critical section. Wherever possible a larger radius than that usually fixed by the gap of the jaw should be used for the inner radius of the beam. Bad construction of the section, due to a too rapid change of section or to too small a fillet, can reduce the strength to half that what would be expected from the theoretical section modulus of the section. The article forms a very interesting experimental confirmation of the assumptions usually made in the theoretical treatment of the subject.—*Dr. F. Uber, Werkstattstechnik,* March 15, 1922; p. 161; 2 pp.; 12 ff.

Economical Ships.

The first part of this article was reviewed in the April "Notes." In this concluding portion the author proceeds to study the application of the formulæ previously deduced for the optimum length, prismatic coefficient and beam-draught ratio. The resistance equation upon which the above are based is examined in the light of available trial data and the fluctuation in the Admiralty coefficient and overall efficiency due to the variation in propeller efficiency is shown considerably to discount the value of the data. As an example the case of the ss. *Kronenfells* is taken. This vessel has a displacement of 15,250 tons, a length of 485·8 ft., beam 62·2 ft., draught 24 ft., prismatic coefficient ·773, and an effective horse-power of 1,817. By application of the data to the optimum length equation it is found that a 3·07 per cent. saving in power and a 19·6 per cent. saving in hull weight was possible if the length is reduced to 400 ft. the prismatic kept constant and the beam and draught increased to 67·8 and 26·3 ft. respectively. Next, the vessel is examined at this optimum length and the optimum prismatic coefficient deduced. This is found to be ·527, which effects a saving of 19·6 per cent. in the horse-power but which necessitates a beam and draught of 76 ft. and 28·5 ft. respectively. The resulting beam draught ratio 2·95 is rarely, if ever, met with in merchant ships although it is common in warships. Next the optimum beam draught ratio is investigated, but in this case practically no change in power is found over a large variation in this ratio. The author next emphasises the necessity for complete trial data, and the recent very complete work of Dr. Bauer on the ss. *Cairo* is considered and the constituent efficiencies of the whole propelling system are very clearly and diagrammatically compared. Finally, reference is made to the recent work of Cleghorn (see *Shipbuilding and Shipping Record,* January 19, 1922) whose recommendation of a Taylor fatness ratio, *i.e.*, $\left(\frac{D}{\frac{L}{100}}\right)^3$ of 240 for cargo vessels of about 12,000 tons displacement and a speed of 12 knots coincides very well with the results obtained from the optimum length equation. In the vessel already considered a fatness ratio of 240 would produce a length of 399 ft. as against 400 ft. found by the author.—*W. Schmidt, Z.d.V.d.I.,* March 18, 1922; p. 257; 3½ pp.; 2 ff.

Torsional Vibrations of Shafts.

The following article is an extension of the work previously given by Dr. Gümbel before the British Institution of Naval Architects in 1902. In it the problem of the damping of the vibrations set up by the action of known disturbing forces is considered. The subject is dealt with under the following heads. First the vibrations of any given mass-system under the influence of given disturbing forces and internal and external friction are calculated; second the various possible means of damping are considered and calculated; third, and finally, the various existing and designed methods of damping are reviewed and commented upon. The treatment of the first two sections is mathematical and deals very completely with the subject. The third portion is based principally upon the methods adopted for eliminating shaft vibration in German submarines during the war. These consist of various mechanical, electrical and hydraulic devices and are illustrated in detail. It is interesting to note that the Föttinger hydraulic transformer can be used to eliminate vibration when correctly placed between the engine and propeller shafting.—*Dr. L. Gümbel, Z.d.V.d.I.,* March 18-25, 1922; p. 252, 281; 7 pp.; 19 ff.

The Integrating Indicator.

A description of an ingenious instrument which at once enables the mean pressure of the steam in an engine-cylinder to be read off automatically is given in this article. The theoretically alternative methods by means of which such a result could be achieved are first discussed and then the practical considerations which modify the theoretical methods are outlined. Finally, the instrument designed by Dr. Gümbel, in the light of these theoretical and practical considerations, is described in complete detail. It consists of the usual indicator-cylinder with outside spring but without the usual registering device. Instead of this, a measuring wheel is placed on the indicator-piston rod and moves bodily with it when the indicator-spring deflects, and is rotated round the rod by two lateral friction discs whose motion is controlled by the usual cord attached to the engine-piston. The total rotation and translation of the measuring wheel is indicated on a registering dial which is so geared that the actual mean pressure is read off. The instrument which also includes a stroke counter is completely enclosed and has been designed and constructed with great care. With the usual type of indicator-cylinder the instrument can only be used for readings on one side of the piston. For a double reading, two instruments are usually necessary, although with a special indicator-cylinder the sum of the mean pressures on each side of the engine-piston may be read off. The indicator can work under normal conditions up to a speed of 500 r.p.m., the likely error being of the order of ½ per cent. For higher speed work the instrument must be specially designed.—*Dr. L. Gümbel, Z.D.V.d.I.,* April 1, 1922; p. 298; 1½ pp.; 6 ff.

Marine Diesel Engines of the Deutsche Werke Company, Kiel.

In 1919 the Deutsche Werke Company, of Kiel, took up the building of slow-running Diesel engines, and in 1921 a contract was secured for a twin-screw installation, each unit having a brake horse-power of 950 and working at 135 r.p.m. The first of these engines was finished in November last and was subjected to a seven days' continuous and successful trial. The engine is of the four-stroke type and has six working cylinders, each of 555 m.m. diam., with a piston stroke of 900 m.m. Three stage air compressors for injection and starting are built on to the main engine and are driven by a beam lever attachment in order to reduce the length of the engine. This beam lever also serves to drive the necessary oil and water pumps. The various parts of the engine are described in detail and a considerable number of detail drawings and photographs add to the completeness of the description. The principal results of the trial are given. The more important being as follows:—I.H.P., 1,280; B.H.P., 950; M.E.P., 71 lbs. per square inch; and fuel consumption (gas oil), ·395 lbs. per brake horse-power hour. Indicator diagrams taken during the trial are also given. The Deutsche Werke also builds a variety of smaller Diesel engines for auxiliary purposes.—*Dr. Rembold, Schiffbau,* April 5, 1922; p. 815; 9 pp.; 15 ff.

Oil Burning in the German Navy and Mercantile Marine.

In the first portion of this article the very varied experience of the German Admiralty with oil burning is reviewed. Commencing in 1893 with the use of Mazout and a Körting burner, innumerable systems were tried and invariably with but little success. Attention was given to simple oil burners and mixed burning of oil and coal but with disappointing results. In 1908 an important set of tests were made on two large vessels definitely to decide on the mixed burning practice. The results of the tests clearly showed the inefficiency of the method and it was therefore discontinued in the larger vessels of that time. Subsequent experience on torpedo

vessels with oil burning led to its partial reintroduction in the larger vessels, and in 1912 the ratio of the pure oil-fired boilers to coal-fired boilers was 1 : 3 in battleships and 1 : 2 in cruisers. Next, the author discusses the advantages and disadvantages of oil as a fuel for naval purposes, after which the war experience of the German Admiralty with oil burning installations is considered. The detail design of the various types of burners is dealt with at length, and then the general lay-out of the oil burning installations is briefly discussed. The various mechanical troubles experienced with each part of the plant are tabulated. Next, the performances of various land installations are detailed and compared with those of similar naval installations. Finally, the question of insulating material, insofar as it concerns the subject, is briefly referred to. In a succeeding instalment of the article the experience of the Mercantile Marine is to be given.—*B. Schulz, Werft, Reederei, Hafen*, April 22, 1922; p. 242; 5 pp.

A New Type of Floating Dock.

Particulars are given of a new floating dock which has recently been designed by the well-known firm of Matthiessen & Müller, of Hamburg. The dock is of the L type but is an improvement on the already existing docks of this type which were first invented by Clark & Standfield. The older type of dock was generally made use of where the space of a works is limited, and because of the unsymmetrical shape of the dock its stability had to be supplied either by side shores connected to the land or by auxiliary pontoons. The ease of docking was its chief advantage, but the above method of providing stability greatly added to the first cost of the dock. To combine the docking advantages of this L dock with the simplicity of the U-shaped dock, Matthiessen & Müller have made the L dock completely stable by merely converting the L dock into a U dock for a short length at each end. The clear space remaining between these two end compartments is sufficient for the broadside docking of average sized vessels, whilst longer vessels can be similarly docked with just a little extra manœuvring. The dock is of the self-docking type and is in four portions—two end and two centre—and any one of these portions can be docked by the remaining three. The wing towers as they are called, which provide the stability, also enable winches to be carried, and this greatly assists in the manœuvring of the vessel to be docked. This new type of L dock can be very simply constructed from the existing and older type of L docks without a great conversion cost. Particulars of the conversion of a 2,100 ton off-shore dock are given. Diagrams of the new dock are included in the article.—*Schiffbau*, April 12, 1922; p. 857; 3 pp.; 13 ff.

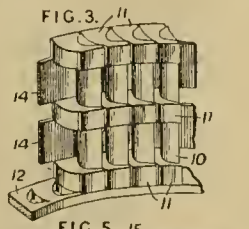
RECENT PATENTS RELATING TO MARINE ENGINEERING.

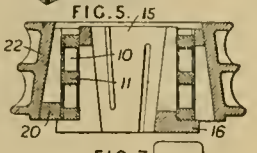
Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

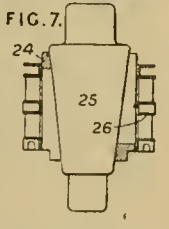
No. 174,996. Turbines.

British-Thomson Houston Company Limited, 83, *Cannon Street, London.*—(*General Electric Company, Schenectady, New York, U.S.A.*) *October* 25, 1920, *No.* 30128. [*Classes* 83 (ii), 83 (iii), 83 (iv), *and* 110 (iii).]

Blades.—Blade rings are formed by building up a complete structure of blade pieces 10, Fig. 3, and distance-pieces 11, and welding the whole together. For assembling, the blade pieces may be placed erect in a pierced ring 12 and the rings of distance-pieces suitably separated and supported by split rings 14. Or the parts may be assembled with or without a pierced ring, around an expandable mandrel comprising a pair of split cones 15, 16, Fig. 5. When the assembly is complete, an outer contractable chuck 20, 22 is forced on to the structure and the mandrel is removed. The inner surfaces are then welded together, the outer chuck removed, and the whole further secured together by welding or by fusion of metal. The structure is then secured again in the chuck 20, 22, is bored, and afterwards is secured on an expanding mandrel 24, 25, Fig. 7, and turned on the exterior. The rings 11 are deeply grooved as at 26, Fig. 7, and a steel ribbon is wound on the grooves sufficient to fill them. The whole is then permanently united by fusion of metal. The structure may be heat-treated, and finally it can be brought to the correct blade pitch by expanding or contracting it by means of the chuck or mandrel.



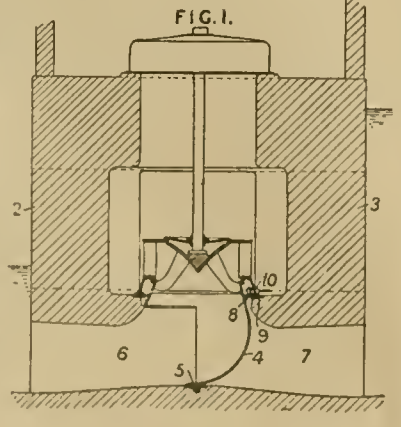




No. 175,192. Turbines.

Lind, G. H., Kristinehamn, Sweden. February 15, 1921, *No.* 5241. [*Class* 110 (iii).]

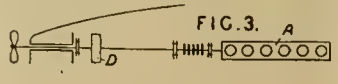
In tidal turbines operated by the alternate flow of water through inlets 3, 2 corresponding to high and low water conditions respectively, the exhaust water is directed in an efficient manner to the proper suction conduit 6 or 7 by means of a valve member 4. The valve 4 has a pivot 5 at the bottom and a flange 8 at the top resting in a recess 9 provided with roller thrust bearings, and it is rotated either by a pinion 10 engaging teeth on the flange 8, or by an axle extending below the conduits 6, 7.

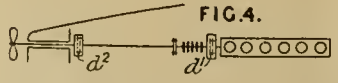


No. 175,244. Propelling Ships.

Krupp Akt.-Ges. Germaniawerft, F., Gaarden, Kiel, Germany. November 18, 1921, *No.* 30865. *Convention date, February* 5. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 7 (ii), 80 (ii), *and* 114.]

When propeller shafts of ships are driven by internal-combustion engines, the arrangement of parts is such that the critical speed of the secondary oscillations of the whole plant is outside the range between the two critical speeds of the primary oscillations. This is effected by placing the flywheel D, Fig. 3, near the tail-shaft coupling and remote from the engine A, or by dividing the mass into two flywheels d^2, d^1, placed as shown in Fig. 4.

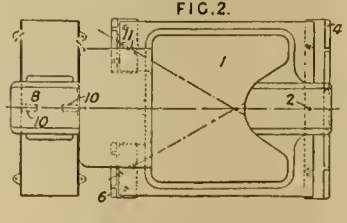




No. 175,551. Turbines.

Baumann, K., Northwood House, Barnfield, Urmston, Lancashire, and Metropolitan-Vickers Electrical Company Limited, 4 *Central Buildings, Westminster. March* 17, 1921, *No.* 8388. [*Classes* 80 (iv) *and* 110 (iii).]

Mounting and supporting.—A turbine casing 1 is supported upon plates 4, 6 and is restrained by a dowel 2 and two or more keys 11, inclined to the axis of the turbine. The keys maintain the correct alignment of the casing when expansion of the casing due to heating occurs. The pedestal 8 is restrained by keys 10 in line with the axis of the turbine.

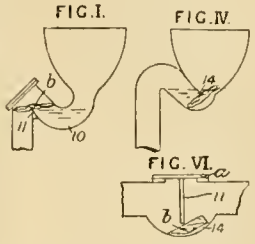


No. 176,443. Ships' Sanitary Systems.

Parsons, W. S., Glymedale, Baring Road, Lee, London. November 6, 1920, *No.* 31,419. [*Classes* 26, 33, *and* 113 (i).]

Relates to sanitary apparatus and drainage systems for ships in which the water closets and other conveniences are led to a common discharge under the action of an expelling machine or apparatus, and consists in the provision of means for preventing objects likely to cause chokages in the lower discharge pipes, discharge apparatus, or valves, from passing through the water-closet pans or along the

discharge pipes. For this purpose the closet basins are formed with a restricted passage having a curved form 10, Fig. 1, in conjunction with an inwardly projecting piece 11, so that any unsuitable substance, such as *b*, is prevented from passing. In the arrangement shown in Fig. IV, the obstructing projection is formed at 14. An obstruction device used in the vertical or inclined discharge pipes comprises a cover *a*, Fig. VI, carrying a plate 11, which projects into a depression 14 in the pipe, and obstructs undesirable substances, such as *b*. The plate 11 may be inclined on the cover *a*, and the sides of the pipe may be bulged out instead of the bottom.

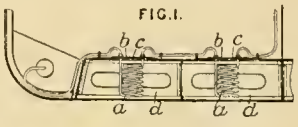


Reference has been directed by the Comptroller to Specifications 4641/83, 22237/98, 21622/05, 5138/09, 10663/10, *and* 13742/14.

No. 176,652. Ships' Tanks.

Zulver, C., St. Helens Court, Leadenhall Street, London, and Endert, D. C., 226, Mathenesserlaan, Rotterdam. February 23, 1921, *No.* 6115. [*Class* 113 (ii).]

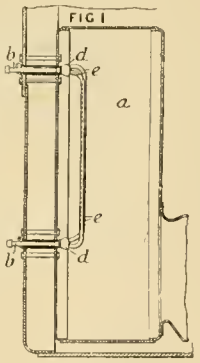
The heating-coils *a* arranged in the double-bottom tanks *d* of ships for the purpose of reducing the viscosity of heavy fuel or other oils stored therein, are carried by plates *b* removably fitted over openings *c* in the tanks.



No. 176,691. Steam Superheaters.

Scott, H. B., Thorner, Barker Road, Linthorpe, Middlesbrough, and Smith's Dock Company Limited, High Docks, South Shields. April 9, 1921, *No.* 10492. [*Classes* 99 (i) *and* 123 (iii).]

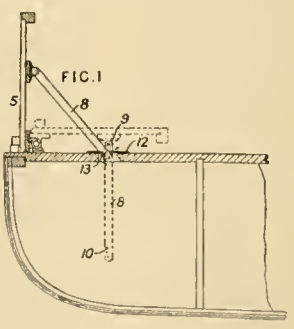
In a superheater placed in the combustion chamber of a marine boiler and connected to outside headers, as described in Specification 159,588, the tubes passing from the headers are branched out inside the combustion chamber into groups of tubes. The group of vertical superheating tubes *e* in the combustion chamber *a* open into enlargements *d* secured to, or formed integral with, the tubes *b* connected to the headers. The superheating tubes may be secured to the enlargements by screwing, welding or expanding. The conical joint between a header and a tube *b* described in the specification referred to above has two or more asbestos, copper, or other metal or composition rings placed between the cone on the end of the tube and recesses in the aperture in the header. The tubes *b* may pass through the boiler smoke-tubes instead of through the back of the combustion chamber.



No. 176,708. Boats.

McLean, K. H., 184, *Crossloan Road, Govan, Glasgow. May* 4, 1921, *No.* 12737. [*Class* 113 (ii).]

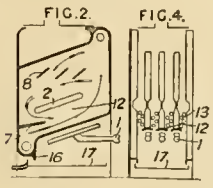
In boats with collapsible bulwarks which are maintained in the erect position by rigid stanchions automatically locked in their raised position, the stanchion consists of a bar 8 hinged at 9 to the bulwark 5 and bearing a notched end 10 which co-operates with a pin 13 bridging a gap in a deck-plate 12 to maintain the bar in the erect position. When the bulwarks are collapsed, the stanchion extends into the lower structure of the boat.



No. 176,760. Sectional Boilers.

Soc. Francaise de Chaleur et Lumière, 115, *Rue Fazillau, Levallois-Perret Seine, France. December* 23, 1921, *No.* 34683. *Convention date, March* 9. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Class* 123 (ii).]

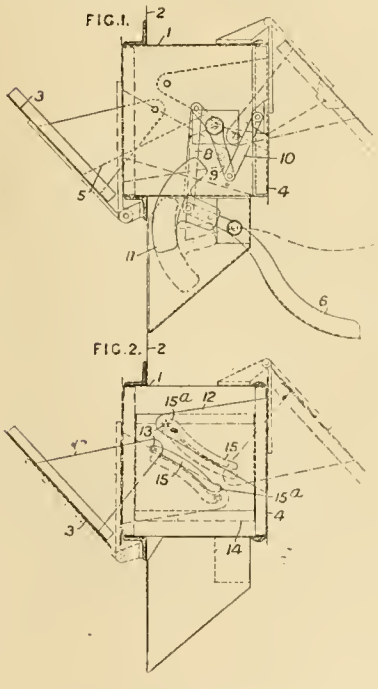
The intermediate sections of a boiler have sloping, depending ribs 12, each bearing a concave baffle under which a gas burner 1 is mounted. Each section has baffles 7, 8 and a partition 2 in the water space to promote circulation. In the case of a steam-generator, the baffles 8 serve to baffle and dry the steam. Between each two ribs 12 refractory balls 13 split up the rising gases. Water condensing on the under side of the elements is directed by a lip 16 to a tray 17. In place of a single upward pass for the products of combustion, they may pass also downward to a chimney at the back.



No. 177,226. Ships' Magazines.

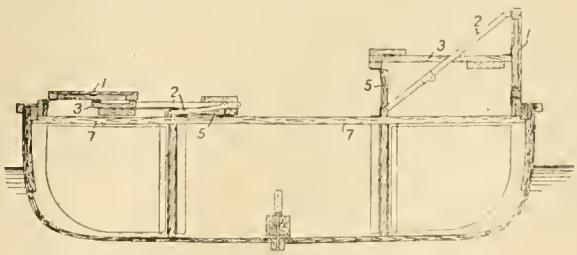
Luck, R. J., Royal Naval Dockyard, Chatham. December 17, 1920. *No.* 35,563. [*Classes* 18, 44, 92 (i), *and* 113 (ii).]

A flash-proof, double-door device for delivering ammunition from the inside of a ship's magazine to the outside comprises a box 1 attached to the bulkhead 2 and having an inner or receiving door 3, and an outer or delivery door 4, to which is linked a pivoted, counterweighted tray 6. The doors are connected so that when one door is open the other is shut and retained against movement, the closing of the inner door releasing the outer door which is opened by the counterweighted tray while the weight of the charge falling on the tray automatically closes the outer door and frees the inner door. For this purpose, brackets 12 on the doors carry pins 13 which engage slots 15 in a vertically sliding plate 14, the doors being free to open and close when the slots are concentric with the door hinges. When, for example, the door 3 closes, its pin 13 passes into an end eccentric portion 15*a* of the slot 15, moves the plate 14 downwards, and brings the slot 15 of the other door into concentric position to permit this door to open. In a similar manner the closing of the door 4 causes the plate 14 to rise and release the door 3. Ammunition is first placed on the inclined bars 5 of the door 3 so that, when this door is closed, the door 4 is automatically opened by counterweighted levers 11, 8, 9, 10, and the ammunition rolls on to the tray 6 carried by the lever 11. Under the weight of the ammunition, the tray returns to the full-line position, closing the door 4 and allowing the door 3 to open and receive another charge.



No. 177,378. Lifeboats.

British Marine Motor & Launch Company Limited, Old Kilpatrick Dumbartonshire, and Howden, W. H., 195, *Scotland Street, Glasgow. March* 7, 1921, *No.* 7242. [*Class* 113 (ii).]

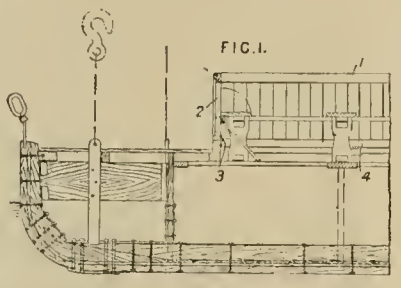


In lifeboats fitted with foldable bulwarks 1 supported in the erect position by hinged jointed stays 2, the seats 3 are designed to collapse with the bulwarks by hinging them outboard to the latter and inboard to a bracket 5, hinged also to the thwart 7.

No. 177,379. Lifeboats.

British Marine Motor & Launch Company Limited, Old Kilpatrick, Dumbartonshire, and Howden, W. H., 195, *Scotland Street, Glasgow. March* 7, 1921, *No.* 7243. [*Class* 113 (ii).]

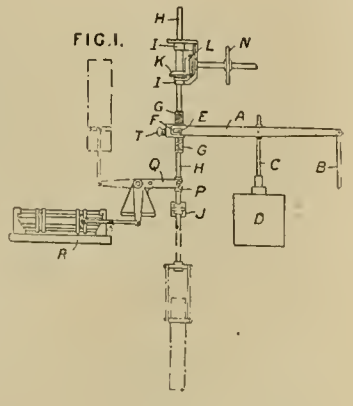
In lifeboats with folding bulwarks the bulwarks are formed as plane fore and aft members 1 working on hinges 4 and plane transverse members 2 foldable on hinges 3 at right angles to the hinges 4, the arrangement being such that the bulwarks enclose a rectangular space.



No. 177,467. Steering Ships.

Wallace, W., of Rosebank Iron Works, Edinburgh. September 13, 1921, *No.* 24310. [*Class* 114.]

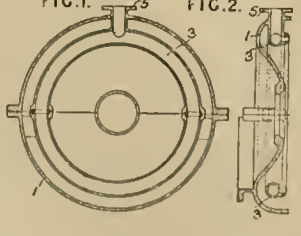
In controlling-gear for steering-motors on ships which include a three-point floating lever wherein one point is attached to the controls, a second point is connected with the rudder, and a third point is coupled to the motor, the control end is adapted to be operated by a telemotor connection or mechanically from the hand-wheel as desired. The lever A has a connection B with the rudder, and a connection C with a variable-speed hydraulic gear or variable delivery pump D. An electric, steam, or hydraulic motor may have its regulating-device similarly connected. The other end of the lever has a jaw-piece carrying in trunnions a nut E. The nut E engages the screw G on a shaft H. This shaft is adapted to be moved endways on bearings I, J by the telemotor gear R, either directly or through levers Q engaging a collar P. When the shaft is so moved it moves the lever A. At the same time it slides in the bevel-wheel K, which is keyed or splined thereto. For operating by hand, the wheel N rotates the shaft H through the bevel-wheels L, K, and thus causes the nut E to traverse the screw G to move the lever. To prevent the shaft from rotating when it should move only endways or *vice versa*, locking-devices T are provided. In a modification, the control is applied at the centre of the lever and the connection C attached to the end.



No. 177,491. Turbines.

Akt.-Ges. der Maschinenfabriken Escher, Wyss, et Cie, Zürich, Switzerland. February 3, 1922, *No.* 3259. *Convention date, March* 24, 1921. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Class* 110 (iii).]

A nozzle ring 3 disposed within a turbine casing 1 is cast integrally with the casing; the inlet branch or branches 5 for the motive fluid form the only connection between the nozzle ring 3 and the casing 1. The casing and nozzle ring may be divided as illustrated, jointing-rings being inserted at the junction. The nozzle ring may be arranged in segments each with an inlet branch.



Orders Placed.—Messrs. James, of Southampton, have secured a contract from the Cowes Harbour Commissioners to dredge the harbour at a cost of £4,800, which is to be paid for as to £3,000 by the Authority and as to £1,800 by the Southampton, Isle of Wight & South of England Royal Mail Steam Packet Company Limited.

INSTITUTION OF NAVAL ARCHITECTS.

Provisional Programme for Paris Summer Meetings.

We have received from Mr. R. W. Dana, O.B.E., Secretary to the Institution of Naval Architects, a provisional programme outlining the arrangements for the summer meetings of the Institution, to be held in Paris from July 3 to July 10 inclusive. On July 4 the meetings will be opened by the President of the Association Technique Maritime, Monsieur Bertin (President of the Académie des Sciences) at the Sorbonne, Rue des Ecoles (Boulevard St. Michel), and the chair will subsequently be taken by His Grace the Duke of Northumberland, C.B.E., M.V.O., President of the Institution of Naval Architects.

It is intended that the following papers shall be read :—

Tuesday, July 4.—At the Sorbonne :—

Papers :—

1. "The Tendency of Warship Design as Affected by the War." Sir Eustace T. d'Eyncourt, K.C.B., D.Sc., F.R.S. (Vice President).
2. "Influence of the Washington Conference on the Development of Certain Types of War Vessels." By Major L. Fea, R.I.N. (Associate).

Wednesday, July 5, 10 *a.m.*—At the College de France (Room No. 3) (adjoining the Sorbonne) :—

Papers :—

3. "Stability of Large Ships." By Sir John H. Biles, K.C.I.E., LLD., D.Sc. (Hon. Vice-President).
4. "New Methods of Testing Materials." By Professor L. Guillet, of Paris.

Thursday, July 6, 10 *a.m.*—At the College de France (Room No. 3) :—

Papers :—

5. "Further Experiments on Contrary Turning Propeller Screws." By General G. Rota, R.I.N. (Member).
6. "Proportions and Block Coefficients of Merchant Steamers." By W. J. Lovett, Esq. (Member).

An attractive series of visits and social functions has been arranged, and intending visitors to these meetings are requested to communicate with the Secretary of the Institution, before June 7. A final programme will be issued to all those taking part in the meetings, together with a personal pass admitting to such of the visits and entertainments as do not require special invitation cards.

Superheaters and Dry Steam (*Concluded from page* 245).

turbines opened up, and he admitted his surprise to find that, excepting for slight tarnishing, the turbine blades showed a total absence of deposit of any kind.

It is always more satisfactory to have a concrete performance of any installation as it gives positive proof of its capabilities. The above performance proves that a waste-heat superheater and purifier, when installed, overcome the difficulties which arise from the presence of moisture and impurities in steam and result in fuel economy and improved efficiency of the machinery installation.

OFFICIAL NOTICES.

THE Proprietors of Letters Patent, No. 107,378, relating to INTERNAL COMBUSTION ENGINES, desire to dispose of their Patent, or to grant licences to interested parties on reasonable terms, with a view to the adequate working of the Patent in this country.

Enquiries to be addressed to :—

CRUIKSHANK & FAIRWEATHER,
65-66, Chancery Lane, London, W.C.2.

THE Proprietor of Patent No. 129,058, for IMPROVEMENTS IN AND RELATING TO SCOTCH MARINE BOILERS, is desirous of disposing of the Patent Rights or of negotiating for the grant of licences to work thereunder.

Communications should be addressed to :—

F. W. GOLBY, Patent Agent,
Late of His Majesty's Patent Office,
3, John Street, Bedford Row, London, W.C.1.

The Marine Engineer AND NAVAL ARCHITECT.

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Mr. John Worthington Pickering, of Holylake, Cheshire, Engineer and Shiprepairer, who died recently, has left £24,048.

Mr. H. M. Bell, who was for many years Engineering Secretary for Workman, Clark & Co. Limited, Belfast, and who retired some time ago, has left that city to reside in England.

Mr. E. H. J. Savenye, Rotterdam, Surveyor of the British Corporation, Registro Italiano & American Bureau of Shipping, has retired. His successor is Mr. I. H. Dijkhuis, and Mr. Ph. E. N. Savenye will be Assistant Surveyor. The office will, in future, be at Heemraadssingel 288, Rotterdam.

Professor Dr. C. P. Holst, Czn, Professor in the Construction of Ship Engines at the Technical University at Delft, has had to retire on account of age, and made it an opportunity for making a valedictory speech. He received the Honour-Doctorate of the Technical University. Dr. Holst intends to publish in English the results of his important studies.

The annual ceremony of selecting the King's Gold Medallist from among the Conway Cadets took place last month when Cadet Thomas Edward Fernie was accorded this honour by a vote of the Cadets themselves, Cadet Frederick Noel Bentley being second, and he therefore becomes the winner of the Tate prize.

Sir William Noble, who has just retired from the position of Engineer-in-Chief to the Post Office, has accepted a seat on the Board of the General Electric Company Limited. It is understood that Sir William proposes to devote his attention mainly to the development of the telephone and wireless sections of this important manufacturing concern.

Mr. A. J. Frey, of Los Angeles, Vice-President of the United States Shipping Board Emergency Fleet Corporation, died on June 13 at the John Hopkins Hospital, Baltimore, of San Josquin Valley disease. This disease proves fatal in most cases, and originally came from China. Mr. Frey was connected with shipping on the Pacific Coast before being associated with the Shipping Board.

Sir Aubrey Brocklebank, Bart., head of the shipping line which bears his name, and a director of the Cunard Steam Ship Company, has accepted a directorship of the Suez Canal Company in succession to the late Sir Thomas Sutherland. The ships of the Brocklebank Line make much use of the Suez Canal. Sir Aubrey is the third holder of the baronetcy, created in 1885, having succeeded his father 11 years ago.

The death has taken place at Southampton of Engineer-Commander Walter Jordan, D.S.O., R.N.R., late of the Royal Mail Steam Packet Company, whose service he first joined in 1884, and later became Chief Engineer of the *Nile* in 1898. During the war period he was Engineer-Commander of the *Andes*, and afterwards returned to his former rank as Chief Engineer. Mr. Jordan was made Commodore Chief Engineer at the beginning of the present year, but had to retire on account of ill-health.

The death took place at Hexham, near Newcastle-on-Tyne, early in June, of Mr. James Bain, who at the time of his retirement some years ago, was Superintendent Engineer of the Cunard Steam Ship Company Limited. Born at Port Glasgow, Mr. Bain served his apprenticeship in the engineering shops of Mr. Robert Napier in Glasgow, at the conclusion of which he spent several years as a sea-going engineer. He was for some time on Cunard paddle-propelled vessels, and afterwards on the ships of the White Star Line. In 1875 he was appointed one of Lloyd's Engineer Surveyors, and remained with that society 10 years, during which time he was stationed in London, Sunderland, and lastly Hartlepool. Mr. Bain rejoined the Cunard staff in 1885, this time in the capacity of Engineering Superintendent, and in the years which followed he was associated with the construction of a long list of notable Cunard vessels, among them being the *Umbria*, *Etruria*, *Aurania*, *Campania*, *Lucania*, *Invernia*, *Saxonia*, *Carpathia*, *Caronia*, *Carmania*, and lastly the *Lusitania* and *Mauretania*, all marking the progressive development of marine engineering enterprise, and the finest examples of efficiency and economy. As the Cunard Company's Engineering Superintendent, and subsequently as General Superintendent, Mr. Bain was to a large extent responsible for the success of these famous vessels, and especially do these remarks apply to the *Lusitania* and *Mauretania*. When in 1903 the late Lord Inverclyde completed negotiations with the British Government for the building of two great steamships capable of maintaining on the Atlantic a minimum speed of 24½ to 25 knots in moderate weather, opinion was divided as to whether reciprocating engines driving three screws, or the marine steam turbine, hitherto untried in large vessels, offered the better solution of the engineering problem involved. Their confidence has been justified by the success of the turbines of the two steamers. Mr. Bain retired into private life shortly after the *Lusitania* and *Mauretania* were put into commission, but he was still retained in a consultative capacity by the Cunard Company. He was a member of the Council of the Institution of Naval Architects and a member of the Institution of Civil Engineers.

EDITORIAL.

THE REVIVAL OF SPEED COMPETITION.

As a sport-loving community we respond with enthusiasm to anything suggestive of a speed competition, whether it be on the road or on our natural element, the sea. In pre-war days, when fuel costs were of less relative importance, and when railway and shipping combines had not, as now, removed to a great extent the stimulus to competitive effort, we had many very fine speed competitions among all manner of vessels, including the Clyde paddle steamers, cross-channel paddle and turbine steamers, Atlantic liners and, from the more grim, strategical point of view, battleships and battle-cruisers. Among the smaller one-funnelled paddle steamers of the Clyde the keenest competition was waged and while this spirit was not, nominally, encouraged by the owners, there could be no possible doubt that, so far as the "skipper" and his crew were concerned, the thirst for a spurt was always prominent. With the arrival of the turbine as a means of propulsion the paddle steamer gradually lost pride of place, although the 20-22 knots of the first of that type were not allowed to pass unchallenged by the more modern paddle steamers. There is presumably considerable commercial advantage to be derived from the possession of the fastest vessel of a given class, and that this is so may be gathered from the competition which has been waged between the several owners of cross-channel steamers, to quote but one example, for the honour of possessing "the fastest cross-channel steamer afloat"—and the satisfaction of advising the public of the fact.

Interest, which the war and the economic conditions associated with its aftermath had tended to subordinate, has recently been considerably revived and stimulated by the very fine speed performances set up by the leviathans of the Atlantic. The most coveted speed distinction of all—the blue riband of the Atlantic—has changed hands several times, and although having been held both by America and by Germany it has now been the proud possession of the Cunarder *Mauretania*, and of this country, for more than a decade. Germany has provided the most serious competition in this connection and it was only with the advent of the *Lusitania* and *Mauretania* that the blue riband was rendered more or less secure for this country. It is a striking tribute to the advanced conception manifested in the design and construction of these Cunarders that the *Mauretania*, although 15 years old, still holds the speed distinction. The remarkable performance of the German-built White Star liner *Majestic*, ex-*Bismarck*, on her maiden voyage, when it was reported that a speed of 27 knots was maintained for a period of several hours, would almost seem to give point to the view, expressed in some quarters, that in producing this vessel Germany not only intended that the *Bismarck* should be, as she is, the largest vessel in the world, but that she should also annex the coveted blue riband. Whether the *Majestic* may be capable of wresting the honour from the *Mauretania* time alone will decide, but the speed performance on her maiden voyage is distinctly meritorious, and considerable credit must be given the ship's engineers in having secured such striking results from a vessel built outside their supervision, equipped with gigantic and complex machinery, and only recently converted to oil-burning. The simultaneous operation of such magnificent oil-burning Atlantic liners as the White Star *Olympic* and *Majestic* and the Cunard *Aquitania*, *Berengaria* and *Mauretania* is entirely without precedent and is likely to be productive of some very fine speed performances during the summer months. We welcome this added attraction to Atlantic travel, and such is the standing of these two great British companies that the travelling public may rest assured that they will countenance nothing which might be calculated to add hazard to the passage, but that their paramount function is to accomplish the safe and comfortable transport of passengers across the Atlantic.

There must inevitably be a certain amount of what may reasonably be described as luck in these fast passages, and more particularly does this apply in the case of a spurt of only a few hours' duration. Conditions of tide, current, and weather play a very great part in the performance of a vessel, and the speed, with these factors assisting, must be fundamentally different from that against them, so that the mean speed of an Atlantic liner on one voyage is frequently vastly inferior to that on another. Given a vessel running acceptance trials over a measured mile under the influence of a 3-knot tide, say, and a favourable wind, her speed relative to the land is conceivably greater than it would be against these elements and, similarly, the effect of a 50 miles per hour wind on the speed of a vessel with the towering superstructure of an Atlantic leviathan must be very substantial. Unless speed records are reduced to a common basis of comparison they are fictitious and, to a certain extent, misleading. The port-to-port time in days, hours and minutes may be assumed to provide a reliable criterion, and on this equitable basis the present Atlantic record of 4 days 10 hours 48 minutes from Daunt Rock to New York, made by the *Mauretania* in September, 1910, may well be taken as a standard for future challengers.

MOTORSHIP PERSONNEL.

The very great advances made in methods of marine propulsion during the last decade, and the increasingly complex nature of the machinery on board ship, have tended to add considerably to the responsibilities of the marine engineer. It has frequently been said that the recent war was an engineer's war, and having regard to the great part played by engineers in the manufacture of munitions and the building of tanks, aeroplanes and ships, the description is doubtless appropriate. During hostilities the success of a naval action was largely dependent on the speed and manœuvring ability of each individual ship, and, consequently, on the capacity of the engineer to produce the best results from the machinery under his control. Realising this, it is not so very long since the Admiralty extended executive rank to engineers as a whole. The examinations for the Board of Trade certificates of competency are subject to a gradual stiffening of the standards of practical and technical knowledge required from candidates; and the shipowner, who possesses a keen commercial instinct, realises that efficient engineers constitute one of the most important contributory factors to the successful operation of a ship. While this applies to steamships as a whole, it is more particularly so in the case of the motorship, where the personal factor among engineers plays a great part.

Each member of a ship's company is, in a sense, indispensable, but, from the point of view of maintenance and operating costs, the chief engineer of a motorship is, we think, the most important. Possibly in no other commercial undertaking more than in the operation of a motorship does a minor official exercise so great a personal control in the matter of authorising expenditure. The consumption of fuel, lubricants and stores and, frequently, the actual purchase of these commodities, is directly under his control. Upon his judgment rests the responsibility for the undertaking of costly repairs. Any lack of discipline or indifference to results may well lead to heavy costs being incurred in distant ports at the hands of unscrupulous repair contractors, when such repairs, under the control of a live and efficient engineer, might have been effected by his own staff. For this reason no two ships are ever productive of similar results on the shipowner's ledger, and although they may be as nearly alike as human skill can devise they must necessarily have different chief engineers,

which is synonymous with different operating costs. In the United States a new wages scale has recently been adopted for chief engineers on Diesel ships, an eight-hour day has been established, and time-and-a-half rates for overtime. We recognise, of course, the need for a graduated scale of wages and working hours, but in extending these regulations to include chief engineers we feel that the best results may not be achieved.

It is no part of our intention to raise a discussion on the question of wages, *per se*, as that is much better left to the parties directly concerned. Having outlined the several functions of the chief engineer, as we have already done, what we do feel is that the best results will be achieved, not by trammelling the scope of his initiative and zeal by a fixed scale of working hours and wages, but by so remunerating the chief engineer that he will feel encouraged to assume the fullest interest and responsibility. Fixed scales are inevitable and obtain in this country as well as in America, although we believe that several motorship owners in this country employ their own scales. To our mind, these scales should only apply in grades inferior to that of chief, who should receive remuneration in accordance with the results achieved. In this way the highest incentive would be given to personal merit, and the position would become more than ever a prize worthy of attainment.

In the present stage of the development of the motorship, the regulations governing the examination of engineers are such as to make it possible, and rightly so, for the steam engineer to qualify for a motor certificate without previously having served time ashore on the construction of motor engines. For example, the holder of a second-class steam certificate may be examined for a first-class motor certificate provided he can produce satisfactory proof of 18 months' service at sea in a suitable motor vessel. These regulations are in force until January 1, 1924, when it becomes necessary for a candidate for a motor certificate to produce proof of shore service on the construction of motor engines. Previous experience in a steamer is an undoubted asset to a motor engineer. Moreover, these regulations have the effect of encouraging the more ambitious and technically competent steam engineers to qualify for service in motor vessels. The motorship has come to stay, and having regard to the increasing importance of the personal factor, together with the higher knowledge of mechanical and thermodynamic principles required of motor engineers, it cannot be other than distinctly to the advantage of the shipowner to accord these engineers the increased status and remuneration which, in the nature of things, is their due.

THE SAFE CARRIAGE OF OIL FUEL.

MARINE engineers are rapidly awakening to the fact that oil fuel possesses many advantages over coal as a means of producing steam on board ship, and as a result quite a large number of vessels now building are being equipped with oil-burning apparatus, the hull being specially constructed so that oil fuel may be carried in double bottoms and in ballast and peak tanks. In addition, many vessels, originally built with the idea of using coal as fuel, are being converted so as to enable them to burn oil, either separately or in conjunction with coal according to the facilities available at the ports to and from which the vessels sail. The question frequently arises, therefore, what is the extent of the changes which must be made to enable a vessel to carry and burn oil fuel. It must not be forgotten that the Board of Trade and the various classification societies have framed the most stringent rules to protect the lives of passengers and crews of vessels carrying oil fuel and also to safeguard the ship herself from the risks involved, and even now these rules are under revision with a view to finding out what special precautions must be taken to prevent fire on vessels with fuel oil of low flash point. The general rules issued by the classification societies refer to the carriage of oil of flash point not less than 150° Fahr., but the Board of Trade insists that for passenger steamships the flash point of the oil fuel shall be 175° Fahr. or upwards, as determined by Abel's close test.

It was found during the war, when the double-bottom compartments were extensively employed for the carriage of oil fuel to this country, that these compartments were, generally speaking, quite suitable as they stood, and if they are able to pass the usual tests for watertightness their use for the carriage of oil fuel is generally approved. The same ruling applies to the fore and aft peak tanks and to any deep tanks, although it must be pointed out that it does not follow that because a tank is watertight it is also oiltight. In constructing oil tanks the spacing of the rivets is generally made closer than is required for watertightness and even so it is well known that a certain amount of leakage always occurs. Provided, however, that steps are taken to deal with any leakage which may occur, the usual watertight construction is deemed suitable. In order, however, to prevent the wash of large volumes of oil from one side of the vessel to the other when the tanks are slack and the vessel is rolling, it is necessary that the centre line division of the tank shall be reasonably oiltight. This is usually done by filling up the drain holes with bolted clamp plates. Riveted patches or jointed blank flanges are not required since it is not necessary to ensure absolute oiltightness. In the case of the forward and after ballast tanks, which are usually fairly narrow, this can be dispensed with. It is laid down by Lloyd's that all compartments intended for carrying oil fuel must be tested by a head of water extending to the top of the filling pipes or 12 ft. above the highest point of the compartment, or the load water-line, whichever is the highest.

When oil is carried in the ballast tanks, the manhole doors must consist of bolted plates secured by means of studs, instead of any form of door which is held in position by means of dogs and screws. It is also necessary that all short air pipes shall be removed and carried up to the decks where they must be provided with goose-necks and wire-gauze covers. The sounding pipes in the machinery spaces must also be carried up to the main deck. There should be four air pipes provided to each of the amidship tanks, and three in the fore and aft tanks for the filling of the liquid fuel into the ballast tanks. A suitable deck connection is provided which is lead from the upper decks down into the engine room, where it is connected to the ballast line. This pipe may also be made to serve the purpose of a deck delivery for discharging oil on shore. The drop-suction pipes into the ballast tanks may have to be lengthened so as to enable the oil to be pumped to within $\frac{1}{4}$ in. from the bottom of the tank, and it is recommended that suitable bell-mouthed strum pipes be fitted. As a rule the usual side coal bunkers will not be found suitable for the carriage of oil fuel since they are not usually constructed for watertightness. It is suggested, however, that they might readily be rendered suitable and that the work would be greatly facilitated by the employment of welding. In new vessels the bunkers are often constructed so that they are suitable for carrying either coal or oil. It is laid down by Lloyd's rules that ceilings must be laid on transverse battens, leaving at least 2-in. air space between the ceiling and the tank top and permitting free drainage from the tank top into the limbers.

It will be seen, therefore, that while the precautions demanded are rather stringent, they do not involve any serious structural alterations, and generally speaking, watertight ballast tanks and peak tanks can be successively employed in the carriage of oil fuel. It may be mentioned, on the authority of a firm who have carried out numerous contracts for the conversion of ballast tanks to oil storage compartments, as showing the efficacy of the precautions insisted upon, that while during the war numerous ships were fitted for carrying oil in their ballast tanks, on no occasion was the cargo affected.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Steam Turbines. By William J. Goudie, D.Sc. London: Longmans, Green & Co., 39 Paternoster Row, E.C. 4. 5½ in. × 8¾ in. × 2½ in. 804 + xviii pp., with numerous plates and illustrations. Price 30s.

The first edition of this book was issued in February, 1917, and as that edition was practically sold out by 1919, the author proceeded with the work of a second edition. A comparison of the two volumes will reveal the extent of the work involved. The text has been entirely rewritten and substantially enlarged, the section dealing with thermodynamics has been based on Callender's characteristic steam equations, two additional chapters have been introduced and some 300 pages have been added. Numerous examples are embodied in the text, and these will be found to be particularly helpful to engineering students. The scope of the work is, however, wider than this, and to the turbine designer, or to the superintending engineer on land or marine installations, this book will be especially welcome.

Dr. Goudie is to be congratulated on having introduced a section dealing with mechanical reduction gears, a feature which, in view of recent discussions, is likely to be particularly welcomed by marine engineers. This work will command a high place among existing literature on the subject, and to those in quest of a comprehensive treatise which takes account of every aspect of the thermodynamics, design, and construction of steam turbines, we commend this book.

Electric Ship Propulsion. By Commander S. M. Robinson, U.S.N.—New York: Simmons-Boardman Publishing Company, Woolworth Building. 9 in. × 6 in. × ¾-in. 274 pages. Numerous illustrations.

This book, written by one who has been very closely in touch with the rapid development of electric ship propulsion, will be read with great interest by a wide circle and by electrical engineers in particular. The many problems which confronted the pioneers in this field of engineering are set forth, and the manner in which these were solved affords valuable guidance to those who may be responsible for similar installations. As is the case with other methods of propulsion, the propeller problem was found to be of primary importance, for the motors had to be designed to suit the torque requirements demanded from considerations of good manœuvring. The installations for several types of vessels are dealt with, ranging from that necessary for cargo ships to those for fast battle cruisers developing close on 200,000 h.p. The arrangement of the book is to be commended; the writer has the gift of clear and concise writing, and the diagrams are models of neatness and accuracy. If any criticism may be offered, it is on the grounds that few details are given whereby an estimate may be made as to the economies secured by this method of developing power. The questions of initial cost, cost of upkeep and fuel consumptions are not considered. The task he has set himself is to show how these installations can be carried out. This he has satisfactorily accomplished. This volume is sure to have a wide sale, not only because it is the first book dealing with this subject from the practical standpoint, but also because of its undoubted merit.

Handelsschiffbau. By Wilhelm Thiess. Hamburg Verlag F. W. Rademacher. 321 + viii pp. 272 figs., 20 photographs and 44 plates. 9½ in. × 6½ in. × 1¼ in. (Price uncertain.)

This book on merchant shipbuilding is written by a practical surveyor, and is intended for the use of students, draughtsmen, surveyors and foremen, and also captains and officers of the mercantile marine. Although not specifically stated, it is an elementary text-book, and is divided into two main sections, the first dealing with calculations, and the second with practical ship construction. In the portion dealing with calculations nothing but the essentials of approximate integration and elementary theory are given. The best treatment in this section is that devoted to tonnage and freeboard, which, of course, might be expected from the author's profession. This treatment takes up one-third of the book—a state of affairs which is easily explained by the fact that the German regulations for freeboard and tonnage are reproduced almost *in toto*! This is undoubtedly unnecessary, for the accessibility of these regulations in pamphlet form could surely be presumed, since in actual practice one would work from the pamphlet rather than from the text book. The remainder of the theoretical treatment is given in a form certainly suitable for the practical draughtsman, and most of the calculations generally carried out, even in the less technical drawing offices, are treated in detail. It is unfortunate, however, that while the metacentric diagram and the inclining experiment are dealt with at length, the calculation of general stability is not considered at all. This is certainly a grave omission, for this is surely an important and by no means uncommon calculation. Apart from the technical treatment of this section, the actual preparation of the diagrams is by no means perfect. Many of the diagrams are unnecessarily large, some extending over two ordinary pages, thus making measurements from these diagrams impossible. This portion of the work could be considerably condensed without loss in efficiency; and if much of the purely regulation portion of the freeboard and tonnage were omitted and some simple method for the calculation of stability (such as that proposed by F. H. Alexander, N.E.C.Inst. of E. and S., 1911) introduced, the text-book would be greatly improved in both treatment and utility.

TRADE PUBLICATIONS.

Ejector Air Pumps.—The first ejector air pump made by the Mirrlees Watson Company, Scotland Street, Glasgow, was installed in 1914. Since 1914 there has been a gradual development in the use of steam ejector pumps, and now, in land work, they are adopted for the largest size turbine units. This company has supplied an ejector air pump for units up to 20,000 kw. capacity. We have received a catalogue on their central condenser type multijector air pumps which are made in 14 standard sizes and are designed for a minimum steam pressure of 100 lb. per square inch.

A.W. Pneumatic Boiler Scaler.—This scaling hammer, which weighs only 4¾ lb. and delivers 9,000 blows per minute, has been specially designed for breaking light scale from boilers and for cleaning up structural steelwork. The air pressure recommended is from 70 to 100 lb. per square inch. It is claimed that the blow is so light no damage is effected to the surface of the metal operated on, while the work is accomplished in a fraction of the time occupied by hand-scaling. The manufacturers are Sir W. G. Armstrong, Whitworth & Co. Limited, Newcastle-on-Tyne.

Hydraulic Presses.—Hollings & Guest Limited, Thimble Mill Lane, Birmingham, have forwarded to us a copy of their list No. A106 showing their hydraulic presses for bundling scrap iron, brass, copper, &c., and suitable pumps and accumulators for same. The average size of bale produced by their largest standard press is 2 in. by 15 in. by 6 in., and weighs about 1¼ cwt. Other types of hydraulic presses are designed for bundling scrap into the shape of the melting pot and for briquetting turnings, borings, &c.

THE CALIBRATION OF OIL TANKS AND THE DESIGN OF TANK HATCHES.

Influence of Trim on Tank Soundings—Calibration Curves—Structural Features.

To a regular reader of the various technical journals, the absence of correspondence relating to the design and construction of oil tankers has led to the belief that the owners are conservative with their views on the subject. Open discussion would, however, only tend to eliminate the many erroneous conceptions prevalent among designers and builders and eventually result in the most efficient ship.

We have frequently had occasion to investigate heavy weather damage sustained by this particular type of vessel, and have often found defective arrangement to be responsible for the damage suffered. Particularly has this been found to apply to deck damage in the vicinity of oil tank hatches and it is therefore hoped that the following remarks on this phase of the subject may prove helpful to those interested.

Cargo oil tank hatches should, where possible, be so allocated that the hatch lid sounding-plug falls at the mid-length of the tank. This ensures the ullaging of the cargo remaining unaffected by the variations of trim of the vessel which must unavoidably take place due to consumption of fuel, fresh water and stores, &c., during the voyage.

In some cases, however, such an arrangement is impossible on account of the position of deck erections. The difficulty of measuring the quantity of cargo in these tanks under variations of trim, can be overcome by having special calibration curves prepared, giving the dips and corresponding capacities in cubic feet at regular intervals of depth and trim, the latter varying from even keel to the maximum anticipated under extreme service conditions. The curves shown in Fig. 1 apply to an oil tank where the hatch is situated at its fore-end with the vessel trimming by the stern.

The angle of trim is easily determined by dividing the difference in the draughts taken at the stem and stern posts by the length of the vessel between perpendiculars; the value so obtained representing the tangent of the angle of trim, from which the angle is quickly determined by reference to trigonometrical tables.

As an aid to accuracy in the determination of capacity at any depth and condition of trim, cross curves should be prepared from those in Fig. 1, showing capacity plotted against angles of trim for a series of depths ranging from zero to a maximum dependent on the service of the vessel.

For any depth intermediate between those represented by the cross curves, the capacity may be determined by direct interpolation.

The accompanying plans illustrate the general arrangement of a petroleum cargo tank hatch. Where these are seated on a strength deck, great care must necessarily be taken in the disposition of butts of deck plating, also in the arrangement of compensating doubling plates in their vicinity.

Adequate provision must also be made to provide for the stresses which tend to congregate at the corners of the deck hatch openings. The latter is most effectively accomplished by adopting a radius at the corners of not less than 12 in. and fitting doublers as shown in Fig 3. Neglect in this respect

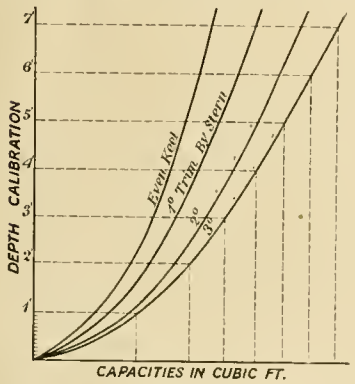


Fig. 1.

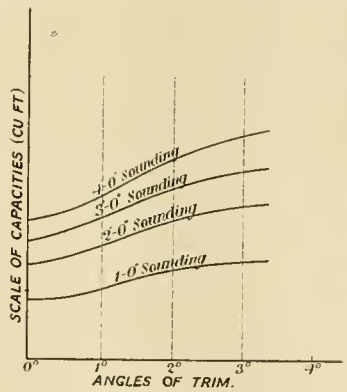
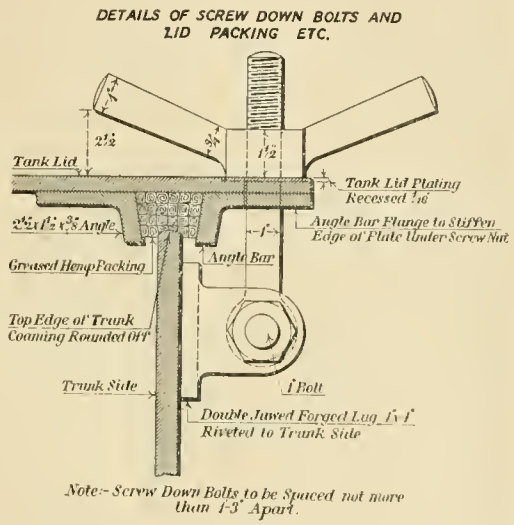
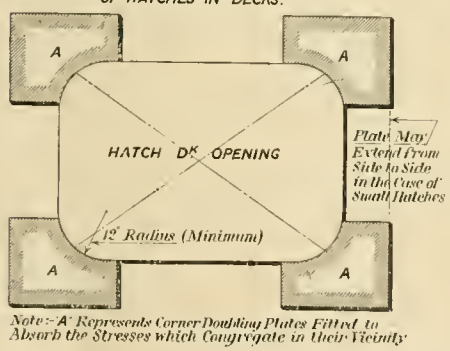
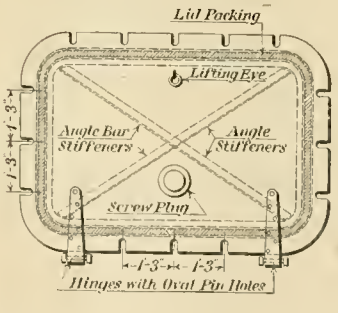
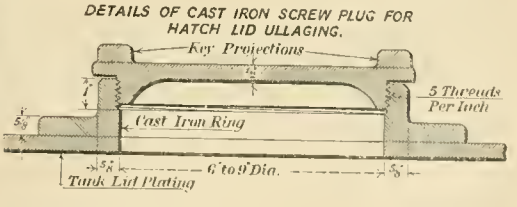


Fig. 2.


DETAILS OF SCREW DOWN BOLTS AND LID PACKING ETC.
Tank Lid
Tank Lid Plating Recessed 1/16
Angle Bar Flange to Stiffen Edge of Plate Under Screw Nut
Angle Bar
Greased Hemp Packing
Top Edge of Trunk Coaming Rounded Off
Trunk Side
1 Bolt
Double Jawed Forged Lug 1'x 1' Riveted to Trunk Side
Note:- Screw Down Bolts to be Spaced not more than 1-3" Apart.


COMPENSATION DOUBLERS AT CORNERS OF HATCHES IN DECKS.
A
HATCH DK OPENING
Plate May Extend From Side to Side in the Case of Small Hatches
12" Radius (Minimum)
Note:- 'A' Represents Corner Doubling Plates Fitted to Absorb the Stresses which Congregate in their Vicinity




DETAILS OF CAST IRON SCREW PLUG FOR HATCH LID ULLAGING.
Key Projections
5 Threads Per Inch
Cast Iron Ring
6" to 9" Dia.
Tank Lid Plating

Calibration Curves and Structural Details of Tank Fittings.

invariably results in cracks emanating from the corners and occasionally in the fracture of the plate. In particular does this apply to those hatch openings situated near the ship's side where the twisting strains in a seaway are most pronounced.

Careful consideration should also be given to the design and construction of the component parts of the hatch lids in order that both oil and watertightness may be ensured.

The method here recommended for securing the greased hemp-lid packing, constitutes, we believe, a departure from present-day practice where it is usually housed in an inverted channel-bar riveted to the underside of the lid. The advantages of this method over the old, will be obvious to those familiar with the subject.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.—IV.

By E. V. TELFER, M.Sc.

In reviewing the general problem of a vessel's stability, it is somewhat significant that it is but rarely the quantitative aspect of the subject is considered. It is generally sufficient to know that positive stability exists over a range of inclinations, such as from zero to 90 deg. With vessels of high freeboard in the ballast condition the quantitative value of moment of stability has to be definitely considered, but generally in most other cases the value of the righting arm is a sufficient criterion of safety. To portray this relative safety it is usual to supply for each vessel constructed a statical stability curve and also a metacentric diagram. It will be remembered that the statical stability curve shows, for a given distribution of cargo and given displacement, the value of the righting arm over a range of inclination. For a given displacement, but varying distributions of cargo, a particular stability curve needs to be modified for the change in the position of the centre of gravity. This modification varies with the shift of the c.g. and the angle of inclination. Thus, if three different displacements are shown on the stability diagram, considerable confusion can exist when the effect of several different positions of the centre of gravity is required. Bearing in mind that the chief function of these curves is for the depicting of comparative rather than quantitative stability, a much more convenient diagram can be constructed by plotting at each angle the value of $\frac{\text{Righting Arm.}}{\text{Sin } \theta}$ This diagram is constructed by the simple conversion of an ordinary statical stability curve. Such a conversion will take the form shown in Fig. 11. Making use of the symbols usual in the terminology of stability, let $\frac{GZ}{\text{Sin } \theta} = \overline{GM}$, or what is the same, let $GZ = \overline{GM} \text{ Sin } \theta$. A little consideration will show that $\overline{GM}$ is just the projection of the righting arm on to the original upright; and thus when GZ and Sin θ are each zero in the upright condition, $\overline{GM} = GM$, the initial metacentric height. If now in Fig. 11, a line BB is drawn parallel to the base line GG at a distance equal to B_oG (= a in Fig. 1 Jan. M.E.) below it, the diagram results in a combination of the ordinary metacentric diagram and curve of statical stability. If, further, the B_oM ordinate is correlated to read also the draught at which each particular value of the metacentric radius occurs, the combination of the two diagrams will be complete. For a given displacement all that is now necessary to characterise the relative stability for various positions of the centre of gravity, is to alter the position of the base line GG by adjusting the distance B_oG to the correct amount. While the underlying idea in this method is by no means new, there is no doubt that its practical simplicity has not received the attention it deserves.

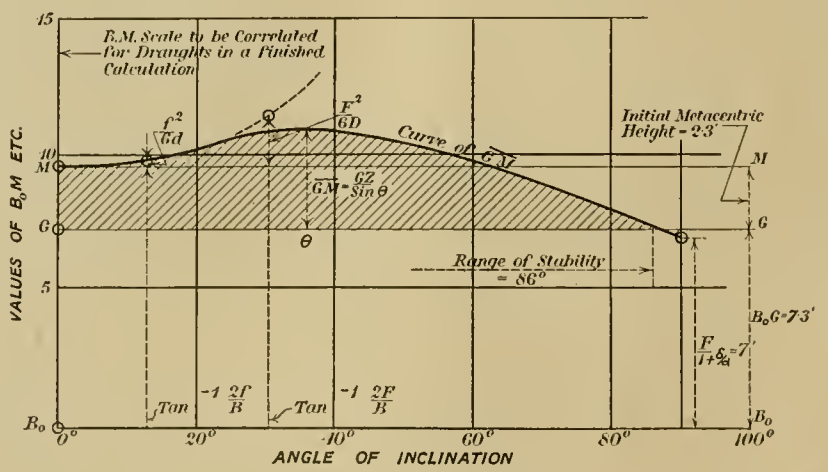


Fig. 11.

We have pointed out that in a stability diagram, only the characteristics of the diagram require to be known, and of these characteristics, the range of stability is probably the most important. It is of some comfort to a ship's officer to know that his vessel must heel over to at least such and such an angle before it will completely turn turtle. But this feeling of comfort ceases to increase with the range of stability, once a practically safe angle has been exceeded. For practical purposes, a range of 90 deg. is as safe as one of 150 deg., in fact, long before even the smaller angle has been reached, the ship itself—apart from the crew—is most likely to have suffered from chronic internal trouble! As a criterion of safety, it can be safely laid down that a vessel should possess as much of its stability before 90 deg. as possible. Considerations of comfort and easy rolling modify this principle to a certain extent, but generally it may be said to hold good. A knowledge of the stability which a vessel possesses at 90 deg. should therefore prove a reliable criterion of the vessel's probable safety. Very fortunately, it is possible to approximate quite closely to the value of the righting arm at 90 deg. without the preparation of complete stability curves. This can be simply shown as follows. In Fig. 12 the prismatic solid of equal length to a basis vessel, whose breadth at any draught is proportional to the coefficient of fineness of this basis vessel's waterplane, is shown floating in the upright condition and also at 90 deg. The freeboard of this prismatic solid is obtained, as in the previous part of this article, in connection with the centre of gravity of homogeneous cargo. The effective freeboard F in fig. 12 will be the sum of the freeboard to the uppermost continuous watertight deck, the mean sheer allowance and the effective height of superstructure erections. We thus have, preserving the symbols used in the previous part of this article,

$$F = f + M + t.e.$$

Considering Fig. 12, it is clear that the value of the righting

arm in the 90 deg. will be the difference between the height of the original centre of buoyancy and the new centre of buoyancy from the original keel line, less, of course, B_oG the separation of the original centre of buoyancy and centre of gravity. Neglecting the influence of the volume contained between the middle-line plane of the vessel and the waterplane at 90 deg., shown shaded in the figure, the centre of buoyancy in the 90 deg. condition may be considered to be coincident with that of one side of the vessel. The effect of neglecting the shaded portion is to give a lower position to B_{90} than is actually the case, but this will be more or less counteracted by the assumption involved in the grouping of the erections. In Part II of this article, Fig. 5, we saw that for normal ships

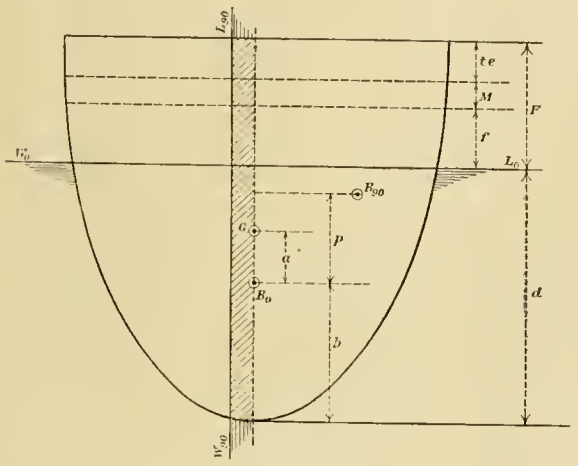


Fig. 12.

the value of $\frac{\delta}{\alpha}$ is practically always constant in the region of and above the load line. Further, we saw that the distance of the centre of buoyancy above the keel was given by

$$b = \frac{d}{1 + \frac{\delta}{\alpha}}$$

Now, since $\frac{\delta}{\alpha}$ can be assumed constant, the distance of the centre of buoyancy of the whole volume of one side of the ship from the keel is given by

$$b_1 = \frac{d + F}{1 + \frac{\delta}{\alpha}}$$

∴ the difference in the centres of buoyancy of the upright and 90 deg. conditions is given by

$$p = b_1 - b = \frac{F}{1 + \frac{\delta}{\alpha}}$$

We may say, therefore, with reasonable accuracy, that the value of the righting arm at 90 deg. is given by the simple expression

$$\frac{F}{1 + \frac{\delta}{\alpha}} - B_oG$$

Dr. H. Schultz, of Hamburg, has published similar work to the above, and has given formulæ, based upon sound fundamental considerations, for the righting arms of vessels of normal type, for angles of 15 deg., 30 deg., &c., up to 90 deg. His work is briefly recapitulated in Johow's Hilfsbuch für den Schiffbau, 1920, page 473. His complete expression for the righting arm at 90 deg. is more complicated than the above, but he shows that within limits his expression reduces to $\frac{F}{2} - B_oG$, which agrees very closely with the above formula for full vessels.

Returning now to the consideration of Fig. 11, or to the projected righting arm diagram, as it may be called, we have now obtained two definite ordinates, the intital metacentric height and the value of GZ and therefore $\overline{GM}$ at 90.° As most merchant ships may be considered wall-sided until almost up to the point where the deck edge becomes immersed, the well-known expression for the righting arm of a box-shaped vessel can be made use of in approximating to the value of $\overline{GM}$ over this range. This expression is usually written

$$GZ = \sin\theta \left(GM + B_oM \frac{\tan^2}{2}\theta \right)$$

therefore from this we have

$$GM = \frac{GZ}{\sin\theta} = (B_oM - B_oG) + \frac{B_oM}{2}\tan^2\theta$$

$$= B_oM \left(1 + \frac{\tan^2\theta}{2}\right) - B_oG$$

to facilitate the calculation of this expression the following Table gives the value of $\frac{\tan^2\theta}{2}$ over a suitable range of inclination.

θ	5	10	15	20	25	30
$\frac{\tan^2\theta}{2}$	·0038	·0155	·0358	·066	·108	·166

As a first approximation, the angle at which the deck edge becomes immersed will be very nearly given by

$$\theta = \text{Tan}^{-1}\frac{2f}{B}$$

and hence the value of $\overline{GM}$ at this angle will be given by

$$\overline{GM} = B_oM \left(1 + \frac{2f^2}{B}\right) - B_oG.$$

Making use of the fact that $B_oM = \frac{f^1(\alpha)}{\delta} \cdot \frac{B^2}{d}$ and, in this case, using the value of $f^1(\alpha) = \frac{\alpha^3}{12}$ recently proposed by Schmidt (Werft, Reederei, Hafen, Feb. 7, 1922), we have

$$B_oM = \frac{\alpha^2}{12\delta} \cdot \frac{B^2}{d}$$

but as $\alpha^2 = \delta$ very nearly, we are brought back to the very well-known formula $B_oM = \frac{B^2}{12d}$. Substituting this in the above formula for $\overline{GM}$, we have

$$GM = \frac{B^2}{12d}\left(1 + \frac{2f^2}{B^2}\right) - B_oG$$

$$= B_oM + \frac{f^2}{6d} - B_oG.$$

Hence, if the quantity $\frac{f^2}{6d}$ be set up above the MM line in Fig. 11 at the angle $\tan^{-1}\frac{2f}{B}$, a close approximation to the $\overline{GM}$ at this point will be obtained. The value obtained, however, will be a maximum value, and for the actual ship the value will be somewhat less. The range up to the deck-edge immersion point should be set off from the general formula

$$\overline{GM} = B_oM \left(1 + \frac{\tan^2\theta}{2}\right) - B_oG$$

and should be extended past the angle up to the angle at

which the effective erection deck edge becomes immersed, *i.e.*, at an angle $\text{Tan}^{-1}\frac{2F}{d}$. The actual $\overline{GM}$ at this spot will be undoubtedly less than $\frac{F^2}{6d}$, but this spot will serve as a guide to the trend of the curve in the remainder of the range up to 90 deg. All that now remains is to sketch in the remainder of the curve to the 90 deg. spot, being guided by considerations of fairness and the extent of erections. By this means, quite a close approximation to the actual $\overline{GM}$ curve of the vessel can be obtained. Very often, of course, the value of $\frac{F}{1+\frac{\delta}{\alpha}}$ is less that B_oG and thus the vessel is unstable at 90 deg., and by drawing in the $\overline{GM}$ curve, the point of vanishing stability can be fairly accurately obtained.

To show the application of the foregoing methods to an actual example, the suitability of a given vessel for the timber trade will be considered. This particlnar vessel has a gross deadweight of 4,000 tons, bunkers, stores, &c., amounting to 400 tons. The principal dimensions and particulars are as follows :—

L = 305 ft.; B = 44 ft.; D = 21.6 ft.; d = 16·6 ft. (bunkers out); δ = ·80; α = ·88; Displacement (bunkers out, 5,000 tons); Sheer aft = 3·4 ft.; fd = 6·8 ft.; mean = $\frac{a+f}{6}$ = 1·7 ft.; 'Tween deck height = 7·0 ft.; poop length = 17 ft.; bridge = 77 ft.; forecastle = 33 ft.; percentage erections = 42 per cent.; under deck volume, 169,000 cubic ft.; height of double bottom = 3·6 ft.; length for cargo = 208 ft.

The centre of gravity of hull and machinery is obtained from the formula

$$g = \cdot 47\ \text{D}\left(1+\frac{\text{M}}{\text{D}}+\frac{2.t.e}{\text{D}}\right)$$

$$= \cdot 47 \times 21\cdot 6\left(1+\frac{1\cdot 7}{21\cdot 6}+\frac{2\times 7\times \cdot 42}{21\cdot 6}\right)$$

$$= 10\cdot 2 + \cdot 8 + 2\cdot 76 = 13\cdot 76 \text{ ft.},$$

the weight of hull and machinery being 1,400 tons.

Assuming that the cargo to be carried is light timber, having a stowing density of 65 cubic ft. to the ton, the weight of the under-deck cargo will be $\frac{169{,}000}{65}$ = 2,600 tons. The remainder of the cargo must be carried as a deck load which, therefore, amounts to 4,000 — 400 — 2,600 = 1,000 tons. This deck cargo is carried in the wells, whose aggregate length is 178 ft., and whose mean beam is 43 ft. The exposed deck load will naturally be liable to be saturated by sweeping seas in heavy weather, and will thus increase in density, say, to a value of 50 cubic ft. per ton. The height of the deck load will, therefore, be $\frac{1{,}000\times 50}{178\times 43}$ = 6·5 ft. This height would correspond to a height of $6\cdot 5\times\frac{65}{50}$ = 8·5 ft. if the wood were of uniform density. This is assumed for purposes of simplicity in order to treat the whole cargo as homogeneous. In this particular case, the bridge 'tween deck space was used for bunkers and cabin stores, which, in the present examination, are supposed to be consumed. As bunkers were also fitted abreast the engine room, the effect of the bunkers on the position of the centre of gravity is practically negligible. We can now find the effective height of the deck cargo (poop and forecastle are assumed empty).

$$\text{Height} = \frac{43}{44}\times\frac{178}{305}\times 8\cdot 5 = 4\cdot 85$$

∴ the effective cargo depth, which is the sum of the depth of hold, and the effective height of deck cargo and the mean sheer (approximate) = 18·0 + 4·85 + 1·7 = 24·55 ft. Now as the length of the cargo space is 208 ft., we have $1-\lambda=\frac{208}{305}$ = ·68 ∴ λ = ·32. In part III of this article it was shown that the centre of gravity of the homogeneous cargo was approximately given by

$$g_1 = w + \frac{\text{D}c}{2-\dfrac{1-\frac{\delta}{\alpha}}{1-\frac{\lambda}{\alpha}}}$$

therefore, substituting the values of the coefficients, we have

$$g_1 = 3\cdot 6 + \frac{24\cdot 55}{2-\dfrac{1-\frac{\cdot 80}{\cdot 88}}{1-\frac{\cdot 32}{\cdot 88}}}$$

$$= 3\cdot 6 + \frac{24\cdot 55}{1\cdot 858} = 3\cdot 6 + 13\cdot 2 = 16\cdot 8 \text{ ft.}$$

Obtaining now the c.g. of the combined hull and cargo, we have

Moment of cargo above keel	= 3,600 × 16·8	= 60,500
Moment of hull and machinery	= 1,400 × 13·76	= 19,400
		79,900

∴ $c.g = \frac{79{,}900}{5{,}000}$ = 16·0 ft. approximately above keel.

From Fig. 9 of part II of this article, or from the corresponding formula, the centre of buoyancy above the keel equals

$$b = \frac{d}{1+\frac{\delta}{\alpha}} = \frac{16\cdot 6}{1+\frac{\cdot 80}{\cdot 88}} = 8\cdot 7 \text{ ft.}$$

Similarly, from Fig. 2 of part I of this article, or from the corresponding formula

$$r = \frac{\cdot 0106\ \alpha + \cdot 0727\alpha^2}{\delta}\cdot\frac{\text{B}^2}{d} = 9\cdot 6 \text{ ft.}$$

∴ Metacentric height = 9·6 + 8·7 — 16·0 = 2·3 ft.

In the above no water ballast is assumed to be carried, for the practice of filling up the tanks as the bunkers and stores are consumed is generally hardly a desirable one, because of the consequent loss of initial stability. As an extreme case imagine a vessel's tanks practically filled with water. With an average width of tank of ·8B the reduction in metacentric height due to the free surface of water is given by $\frac{i}{\text{V}}$ which equals

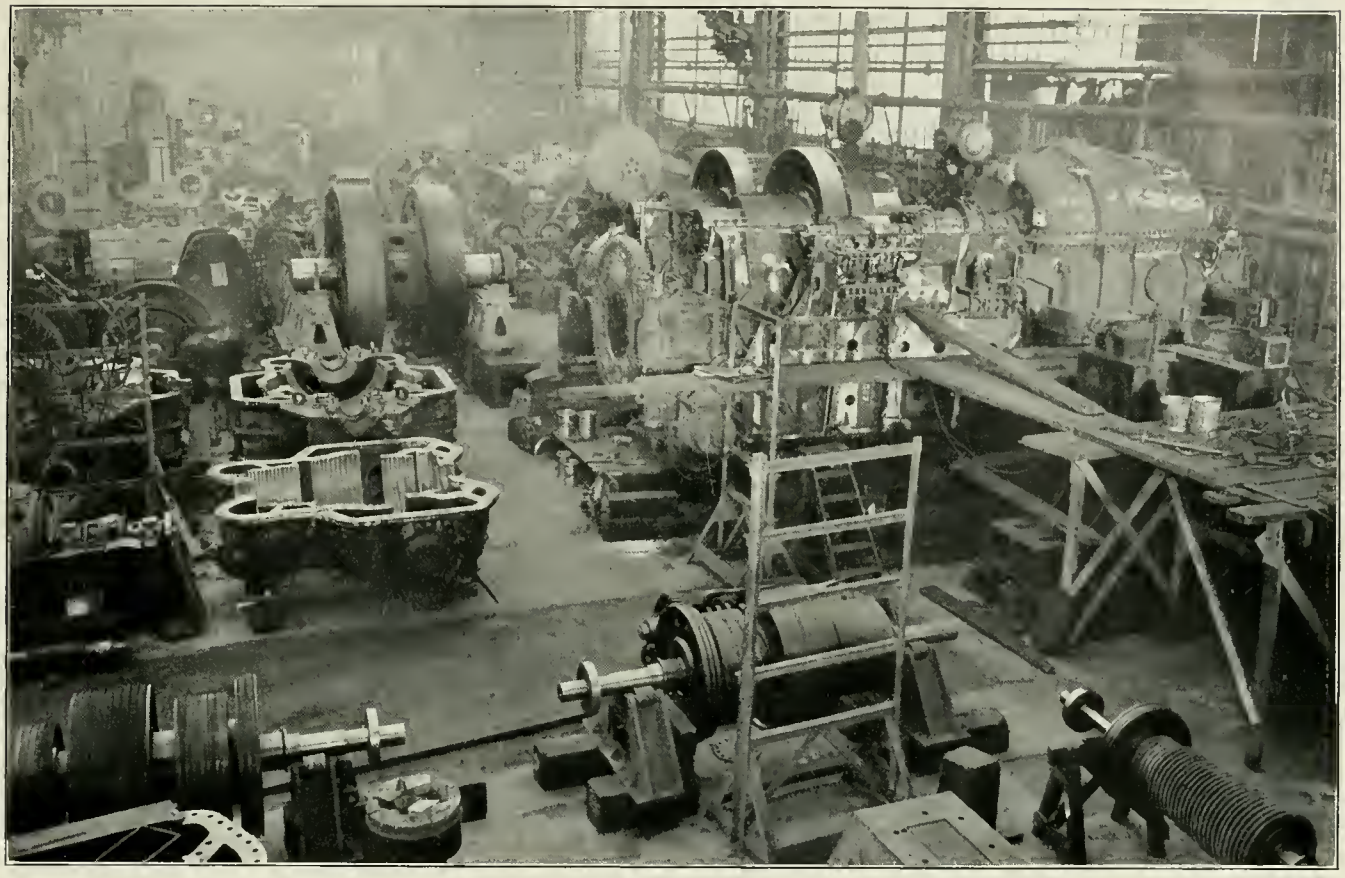
$$\tfrac{1}{4}\cdot\frac{f^1(\alpha)\ .\ \text{L}\ .\ (\cdot 8\,\text{B})^2 d}{\text{L.B.}\,d\,\delta},$$

the factor $\frac{1}{4}$ being introduced because of the watertight centre division in the tank. The whole expression reduces to approximately ·16 B_oM. In our particular case this would mean a reduction of metacentric height of 9·6 × ·16 = 1·54 ft. Hence the final metacentric height equals (2·3 — 1·54) = ·76 ft.

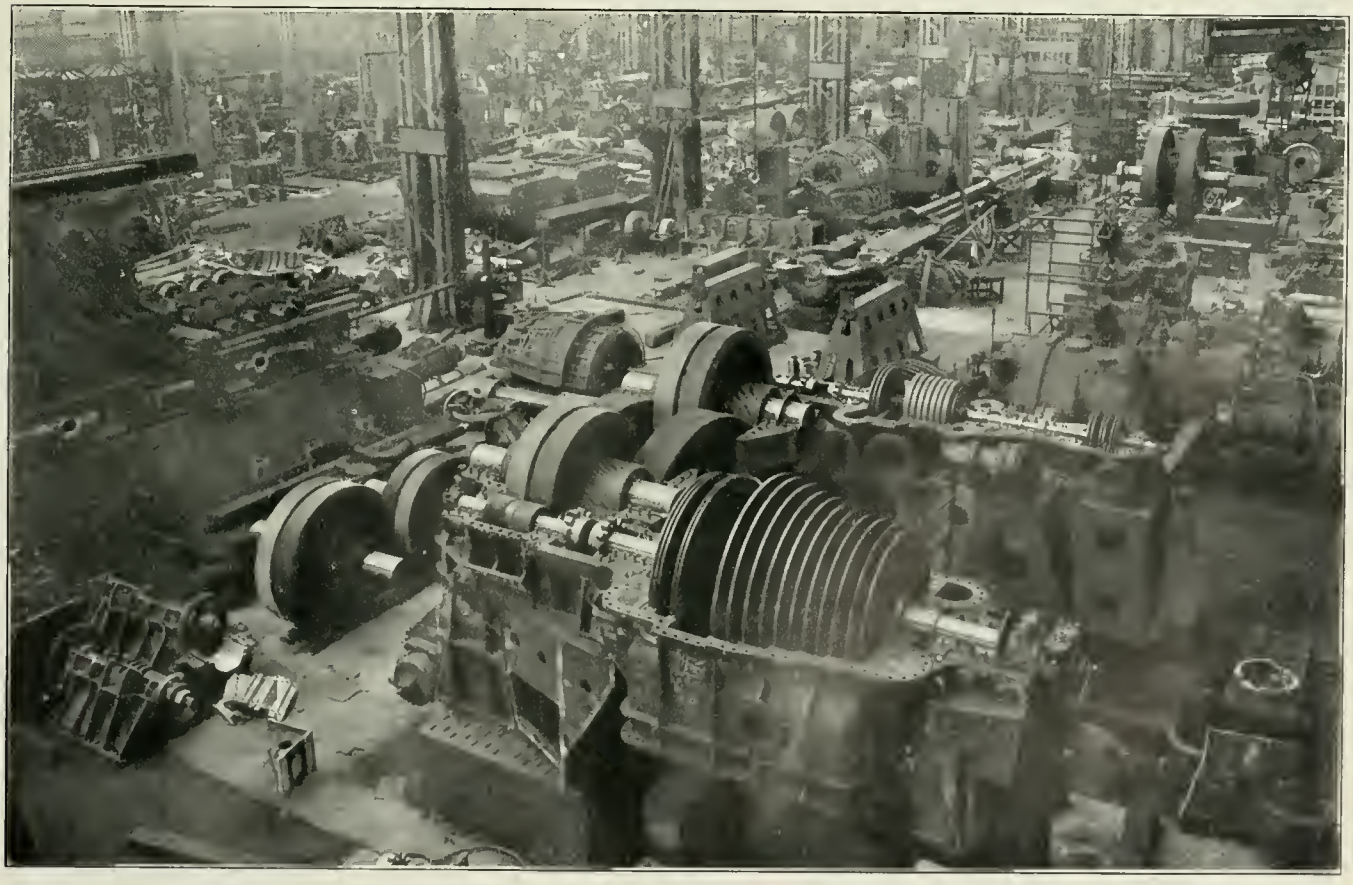
From this result we can say that, so far as initial conditions are concerned, the ship will be perfectly stable, but incidently, it could not have safely had an appreciably greater $\frac{\text{length}}{\text{beam}}$ ratio. Extending the examination to the range of stability, the $\overline{GM}$ diagram is shown in Fig. 11. This is constructed assuming no water ballast to be carried. The effective freeboard of this vessel will include the effective heights of the deck cargo and the bridge 'tween decks, in addition to the

(*Continued on page* 288.)

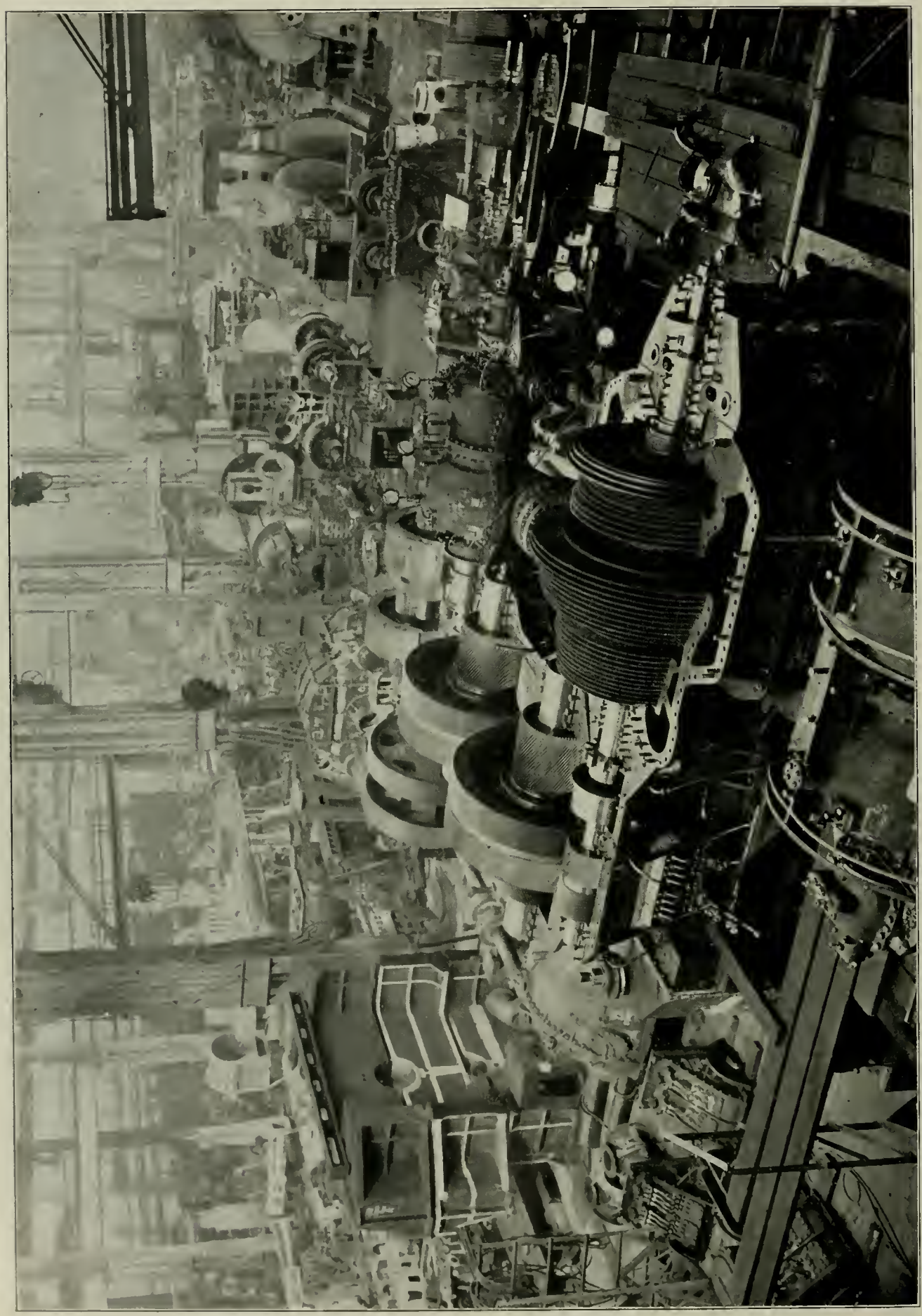
WM. BEARDMORE & CO.'S ENGINE SHOPS AT DALMUIR, GLASGOW. (*See page* 288.)



Starboard Turbines and Gears for New Twin-Screw Cunard-Anchor Liner "Tyrrhenia."



Another view of the Turbines and Double-Reduction Gears for the "Tyrrhenia."



Wm. Beardmore & Co.'s Engine Shops, Dalmuir, showing in foreground Turbines and Gears for Italian Liner "Conte Rosso." (*See page* 288.)

INSTALLATION OF MACHINERY IN SHIPS AT THE FITTING-OUT BASIN.*

Operations Preliminary to Launching—Precautions to be observed at Fitting-out Berth—Progress and Classification of Work.

To begin with, let us note the work that is necessary to be completed before launch. Obviously the first consideration relates to the openings in the ship's skin, and the positions of sea valves will be marked off in order to allow the pattern-maker to lift sweeps for making the branches of the larger chests to place. These branches are provided with chipping strips to facilitate bedding to the ship's plating. The sea chests and cocks are usually jointed with two-ply canvas and red lead, and the flange cemented after jointing, though I never could see that the latter was either necessary or desirable. Next we are concerned with the stern tube and shaft line. The length of tunnel from stern frame to engine seating should be checked and figures given to D.O. to enable closing length of shaft to be machined.

Boring-out for Stern Tube.

Sighting and marking for boring-out for stern tube can be done as soon as the ship is riveted from the engine-room aft up to the lower deck, and all testing of tanks from boiler-room forward bulkhead to stern is complete, with the exception of the aft peak, which, of course, cannot be tested till the stern tube is in place. The sights should be at forward and aft ends of engine-room, one in aft peak bulkhead and one in each end of the boss. If the tube is over 16 ft. long a sight should also be placed in the middle of the length so that a centre bearing may be set up accurately on boring bar. The holes in the sights should not exceed $\frac{1}{2}$ in. in diam. Care must be taken to see that these holes are not enlarged by some obliging foreman who wants you to see a good light when looking through the sights. To see the light at forward end of engine-room, possibly 200 ft. away through five sights, means that three of these sights must be very accurately adjusted. Before sighting in ships which have a large overhang aft, such as battleships, cruisers, and destroyers, great care must be taken to ease the keel blocks and shores, to see that there is no undue strain, and that the stern is as near as possible to what it will be when water-borne. It is quite common for the stern of these vessels to come down as much as $\frac{3}{8}$ in. when eased to suit these conditions. To save time, gear case and turbine chocks are cast, machined and drilled to drawing, having $\frac{1}{2}$-in. allowance left on for machining to gauges taken from place. Most of this allowance is necessary to take up inequalities of the seating and not much is left for breakage of ship. Having sighted, it is necessary that proof marks should be scribed on boss, bulkheads, and inside stern frame larger than the bore, in order to check position of the bar while boring, and also to facilitate the subsequent setting-up of shafting in tunnel.

After boring, always sight again to prove whether boring has been done correctly, and the facing of boss should be checked to see that it is square with bore. Sizes for finally turning and making to length of stern tube may now be taken, and the stern tube jointed in place when ready. A wire should be stretched through sights at fore and aft end of engine-room, and main engine seats checked from it, auxiliary engine seats and boiler stools should also be checked now.

Where practicable it is a good plan to set up all tunnel shafting and plummer blocks before launch, as this allows gear case or bedplate to be set as soon as it can be lifted on board. The plummer blocks should be bedded on about $1\frac{1}{2}$ in. solid teak.

The propellers should be allowed to revolve at launch, if not required to be fixed for checking the way of ship, as this greatly reduces the thrust and consequently reduces the shoring off of shafting for launch. Floor plate bearers in boiler-room, and in wings of engine-room, should now be complete.

All work in double bottoms should be finished before launch, such as stem heating in O.F. tanks and ballast suctions, as if this work has to be done afloat, rain and other water will gather in the tanks, making it impossible to get the work done as well or as quickly as on the stocks. It may be noted that in the latter case, rivets are left out for draining tanks. Prior to the launch, care should be taken to overlook the skin fittings as a whole, and to compare sea chests with drawing to see that none are forgotten, and immediately before launch, sea valves should be shut and hand-wheels removed or blanked to avoid accidental flooding.

Installing Machinery at Fitting-out Berth.

After launch, the vessel is placed under the crane in the fitting-out basin, and the engineers begin to take an increasing share in the work, as while the vessel is on the stocks there are usually only light derricks of 3 to 5 tons' capacity, and even at that, the only time the engineers can get the use of them is when the platers, carpenters, and other shipyard workers do not require them. In fact, engineers in a shipyard are always considered by the shipyard management as nuisances necessary certainly, but nevertheless nuisances. Even the engine works' authorities look on the outside engineer more as an outsider than an engineer. At the best, they seem to regard him merely as an assembler of parts, a pipe jointer, just a man to break drills and not to be trusted with good tools, and when it comes to trials, as an engine driver.

Before shipping boilers or other heavy machinery, the actual clearance should always be checked to ensure it being sufficient, for the shipbuilders have an idea that sundry beams and stiffeners sticking out here and there do not matter at all. Even some engineer draughtsmen seem to think that an 18-ft. boiler will go down an 18ft. 3-in. opening, forgetting such trifles as butt straps, rivet heads, and boiler slings, and in the engine-room they often place heaters, auxiliary condensers, and lubricating oil coolers close up under the deck without leaving any space for the chain blocks to lift them into position. Other points to remember are the slings above the boiler, also the size of the crane block. In ships with fine lines, the probability of the vessel taking a heavy list while shipping boilers should be borne in mind.

If shipping space and weight allow, the boilers should be shipped complete with smokeboxes, superheaters—all tested—furnace fronts, firebars and brickwork, as this can be done much cheaper in the shop or on the quay than when everything has to be man-handled in the narrow spaces available down below.

Simultaneously with the boilers being placed on board, the main condenser and auxiliary machinery will have been placed in their corners; every effort should be made to secure delivery of auxiliaries by date of launch; the draughtsman usually places these things very neatly in corners where they are very awkward to get at an overhaul. Now it is always the machine that is most difficult of access that requires the most overhauling; just because it is awkward to get at, the overhaul is postponed from time to time, in fact, till it can be left no longer, and then it usually means a big job.

* Abstract of Paper read to the Greenock Association of Engineers and Shipbuilders, November 8, 1921, by Mr. H. E. Royston, and published in the March-April *Channel*.

The main gear case can now be put on board and set up to the shaft coupling. The bottom of this must be machined to allow for properly fitting cast-iron chocks. After the gear case is set and secured by a few bolts and chocks, the turbines may be placed in position and gauges made for machining all chocks.

Gear cases and turbines always sit on specially built seats, and no question should arise of bolts fouling rivets. In a bedplate for a reciprocating engine, however, a templet taken of the holes in the bedplate should always be made and tried down on the tank top to see if any bolts foul rivets, in which case these holes must not be bored, but new ones drilled in bedplate and tank top which will clear. As the tank under the engines usually carries fresh water for boiler use, the bolts require to be screwed through the tank top and nutted above and below. The size and number of bolts is more important here owing to the working of the engine. I may say that I was at sea with a job that used to break 20 to 30 bolts every voyage.

Subsidiary Fitting-Out.

The principal parts of the machinery and the boilers being in place, the coppersmith comes into prominence in connection with the pipe work. Given a good level-headed draughtsman on the pipe arrangement and careful work in setting up auxiliaries, it is good practice to finish off complete, with flanges faced and drilled, about 50 per cent. of the pipes; the remainder will be about equally divided between pipes with loose flanges and pipes made to set taken at the ship. The speed at which the copper shop can complete these made-to-place pipes, fixes the date of basin trial. Every effort should be made to avoid making castings to place as these always cause delay.

All joints which are subject to vacuum in a turbine job should have both sides painted with red lead, and after the joint is made, the outside edges of the flanges and also the bolts and nuts should have three good coats of red lead paint. To get a vacuum of 29-in. when running at full power makes it necessary to omit nothing in the way of precautions. Bilge, ballast, sanitary and other water pipes are jointed with the ordinary insertion. If, however, ballast pipes may be used for oil fuel suction, they are usually jointed with $\frac{1}{8}$-in. cardboard.

Very careful attention should be given to the drain system. Drain cocks placed in suitable places and made easily accessible, go a very long way to prevent accidents. They also save the joints in pipes and extend the life of all piston rod and valve spindle packings tremendously, especially where metallic packing is used in the auxiliary machinery. Drains from all pipes should be collected in funnels and led to hotwell or float tank. Drains from cylinders should be led to bilges.

Wherever possible, bosses for taking drain cocks should be cast on valves instead of brazing on to pipes, especially now that steel pipes are so largely used.

Lagging is a very important question, and to my mind does not get the consideration which it deserves. The general specification of the machinery and boilers too often contains a clause much as follows:—"The boilers, turbines, and pipes to be covered with an approved non-conducting material of a suitable thickness," and it is usually left to the commercial department to fix up something cheap and nasty. What do they know about the relative values of hair-felt, asbestos-rope, asbestos-faced felt, magnesia sections and slabs, asbestos-cloth and canvas, and the many boiler compounds? The above quoted clause also gets into the quotations for auxiliary machinery, and you get something different from every auxiliary engine-maker in the way of lagging on their cylinders, and very seldom done efficiently. What is the use of fitting superheaters to boilers and treating the lagging in this haphazard manner?

No fitting-out basin is complete without a small workshop, containing a number of vices, grindstone, smiths' forge, coppersmiths' fire, pipe-facing machine, horizontal and vertical drills, power-hack saw, sensitive drill for small holes, blower for the fires, and motor for driving these machines. An under-foreman should be in charge of this shop, and any drilling, cutting, or smiths' work should be given to him to be done by his men at the machines and fires, and not done by the ship fitters themselves, as in that case it would be nobody's business to take care of the machines, drills, and saws.

The smith will make all hand-rails, pipe hangers, and brackets required, except any really heavy work or such work as can be sent to the shop some time before it is required. All pipes marked at the ship should be drilled and faced in this shop as they are always in a hurry. It is never satisfactory to send work back to the engine works to be finished, especially pipes, as you cannot afford these to be for hours and sometimes days without being touched. No one there ever seems to realise the urgency of getting these into place at once, the want of one pipe probably holding up a whole range, preventing you from raising steam or starting your forced lubrication. You may say that these are special cases, but I have found that even in these, the works manager will tell you that your jobs must just take their turn, as they have equally urgent work of their own.

The refrigerating chambers are always left by the shipyard to the last minute. For some unfathomable reason there always seems to be a difficulty about arranging for the insulation contract for these spaces and this work is usually started about the time the engineers have steam up and are waiting to run the freezer. Even after the insulation of the chambers is complete the brine pipes have to be fitted to place and tested when complete, and not till this is done can the brine pipes themselves be insulated in the machinery spaces.

The outside manager usually has complete control over engineers, boilermakers, and slingers. Coppersmiths, blacksmiths, brass-finishers, sheet-iron workers, and joiners generally come from the engine works. Now if you have no control over starting or paying-off men, you really have no hold over them at all, and you have to work through the various engine works' foremen of these departments, which makes for delay. Another disadvantage is that these men lift and deposit their tickets in the engine works, causing further delay.

Classification of Work.

The outside manager should also have some say in the Progress department, because, after all, the date of completion is really up to him, and this is the date to which everyone should be working from the start.

The main engines and boilers are always kept in view by the works' manager, to be ready for date of launch, and he is inclined to think his job is finished when these have been sent to the fitting-out basin. He is apt to regard the thousands of pipes and fittings required in a modern forced lubrication and oil-fuel burning installation merely as ordinary routine work, which will more or less look after itself. Exhaust tanks, forced lubrication tanks, oil coolers, furnace mountings, watertight doors, and other large fittings are treated in the same way. Sometimes there is delay in getting these out from the D.O.

Everything should have a priority number, given according to the order in which the various fittings are required to be worked into the job.

Having given these priority numbers, every effort should be made to see that they are worked to, and no excuses from shop foremen should be accepted for any departure from them.

PRIORITY LIST.

Priority Number.	Pipes and Fittings.
1	Gearcase and turbine mountings and pipes. Boiler mountings and pipes. Launching fittings and pipes. Watertight doors and gear. Oil-fuel steam heating fittings and pipes. All bulkhead and deck pieces.
2	All under-floor fittings and pipes.
3	Oil storage, gravity, and reserve tanks. Exhaust tank, feed tank, and their respective mountings.
4	Main and auxiliary steam, feed suction and discharge, air pump suction and discharge, and other water pipes and fittings not included under 1 and 2.
5	Everything not previously mentioned.

Basin Trials.

Preparation may now be made for basin trial. The forced lubricating system being started, a complete turn should be taken with the turning gear and the gear disconnected. Steam should be put on the glands and the circulating and air pumps started. The air pump should discharge to the bilges during basin trial. Clean and oil the turbine sliding feet and see that they are free to move before warming up. Steam should now be admitted through the main steam system from the boilers, having the bulkhead or emergency valves full open and the regulating valves to turbines both ahead and astern just off their faces. Auxiliary exhaust to L.P. turbine should not be used for warming up. To my mind this is a useless fitting altogether.

Turbines will be warm enough to run in from 2 to 4 hours according to size. Vacuum should not exceed 5-in. during warming up, and only increased to 28-in. just before starting to run turbines. During the basin trial, all by-pass valves and emergency shut-off valves, also all closed exhaust valves and drains should be carefully tried.

Turbines should also be run astern as fast as safety will permit in order to discover any steam leaks, as when running ahead these leaks will be under vacuum, with possibly disastrous results to a high vacuum.

After basin trial and setting safety valves, the back ends should be inspected and any leaky tubes or stays made good. The boilers should be pumped out, cleaned and filled. One pound of quicklime for every four tons of water should be slaked and the milk of the lime, thoroughly strained, should be poured into the boiler. The boiler should then be filled completely.

All defects having been made good, the vessel will now be ready for sea trials, when the same procedure will be carried out, with the addition of four important operations, viz., trying steering gear, whistle and telegraphs, also moving engines slowly ahead and astern before reporting to the bridge, "all ready for sea."

Completion Dates.

With regard to dates for completion, I submit that it is useless for directors to send out lists of dates which they know are impossible to achieve, in the hope of hurrying up the work, as these lists soon come to be regarded by all concerned as a pure farce. A better plan is to make milestones in each contract, get the deparments concerned to give definite dates for these, and see that they keep them. I have always found that when you ask a man how long he will take to do a certain job he always under estimates the necessary time, that is if he is worth his salt, and of course you don't ask the others. Well, when he has given you the date, do your best to help him to keep it. You will say that some men would always give a safe date; quite so, but I also would keep them at a safe distance.

The table below gives a comparison of the number of pipes and fittings, also engine-room auxiliaries in reciprocating and double-reduction geared boats, both single and twin screw of similar powers, both oil and coal burning. It can easily be seen how much the engineer's job has increased. You will agree that although the machinery spaces are very similar in these jobs, the time taken will not vary directly with the number of pipes, &c., but rather as the congestion increases. In some cases the under-floor pipes present a serious problem. Superimposed on the usual bilge and ballast, feed and other suctions of the reciprocating job you have to find room for a host of forced lubrication suction, discharge and drain pipes, turbine cross connection and eduction pipes, turbine drains and the oil fuel suctions, together with the suction strainers for both lubricating and fuel oil.

Comparative Numbers of Pipes and Fittings in Vessels with Steam Reciprocating and Geared Turbine Engines.

Particulars.	Single Screw.		Single Screw.		Single Screw.		Twin Screw.	
Vessel	A1.	A2.	B1.	B2.	C1.	C2.	D1.	D2.
Engines	Recip.	D.R. turbines	Recip.	D.R. turbines	Recip.	D.R. turbines	Recip.	D.R. turbines
No. of boilers	2	2	3	4	6	4	3	3
Dia. × length	17′1½″×21′0″	17′1½″×21′0″	15′0″×12′6″	15′9″×11′6″	15′4″×11′0″	16′6″×12′0″	15′9″×21′0″	15′9″×21′0″
Draught	F	F	F	F	Nat.	F	F	F
Donkey boiler Diam. × length	13′4″×10′0″	13′4″×10′0″	11′0″×9′6″	None.	12′0″×11′0″	None	None	None
Fuel	Coal	Coal	Coal	Coal or Oil	Coal	Coal or Oil	Coal	Coal
Horse power....	4,800 h.i.p.	6,000 s.h.p.	3,100 h.i.p.	3,150 s.h.p.	4,850 i.h.p.	4,250 s.h.p.	5,500 i.h.p.	6,800 s.h.p.
Weight—tons "Steam up"	1,025	1,050	570	804	1,160	915	1,265	1,275
No. of pipes	801	1,510	418	1,600	925	1,420	977	1,862
No. of fittings	863	2,028	586	1,624	899	1,628	1,773	3,081
No. of auxils.	21	31	13	26	19	31	25	41
No. of winches	18	19	10	15	10	16	27	27

"Number of Auxiliaries" includes usual Engine-Room and Boiler-Room Auxiliaries and the Steering Engine, Auxiliary Condenser, Oil Cooler, Filter Tank, Feed Heaters, and Evaporators.

The Calcutta Dock Strike.—On June 9, says Reuter, the dock strike still continued. The strikers were apparently inclined to resume work, but the stevedores laid down terms which had not been accepted. Work was proceeding on a few ships by means of imported labour

Quick Loading at Cardiff.—Quick loading is still possible at Cardiff. On May 31 last, at 4.15 p.m., the steamer *Loyal Citizen*, owned by the Loyal Line Limited, Cardiff, commenced to load a cargo of 6,000 tons of coal at Cardiff, and at 2.50 p.m. on June 2 was completed.

LUBRICATION AS IT CONCERNS THE ENGINEER.

Natural and Forced Lubrication—Reynold's Wedge Theory and the Michell Thrust Block—Selection Specifications—Graphite as a Lubricant.

When it is realised that of the total power developed in the cylinder of a steam or Diesel reciprocating engine some 25 per cent. or more is dissipated in overcoming friction, the vital importance of reducing all frictional losses to the minimum will be fully appreciated. By the exercise of cleanliness and the careful selection and method of application of the lubricant most suited to the special circumstances, the engineer has it in his power to eliminate to a certain extent the frictional loss in the plant under his control, and to this end no effort should be spared.

There are two principal methods of lubricating bearings. In one method the oil is introduced at atmospheric pressure, and in the other it is forced in at such pressure as the conditions demand by means of a pump suitably driven. These two methods, while serving the same end, are yet fundamentally different inasmuch as in atmospheric lubrication the lubricant is admitted at the point where the pressure on the bearing is at a minimum, while in forced lubrication it is introduced at the point of maximum pressure.

With the increasing adoption of high-speed engines, and the introduction of the Diesel engine, greater loads have been imposed on bearings, and the older forms of natural lubrication have been found to be inadequate, and have given place to forced lubrication. The three systems of natural lubrication most generally adopted in practice are Needle Lubrication, Syphon Lubrication, and Ring Lubrication, and these three are shown diagrammatically in Figs. 1, 2, and 3, respectively.

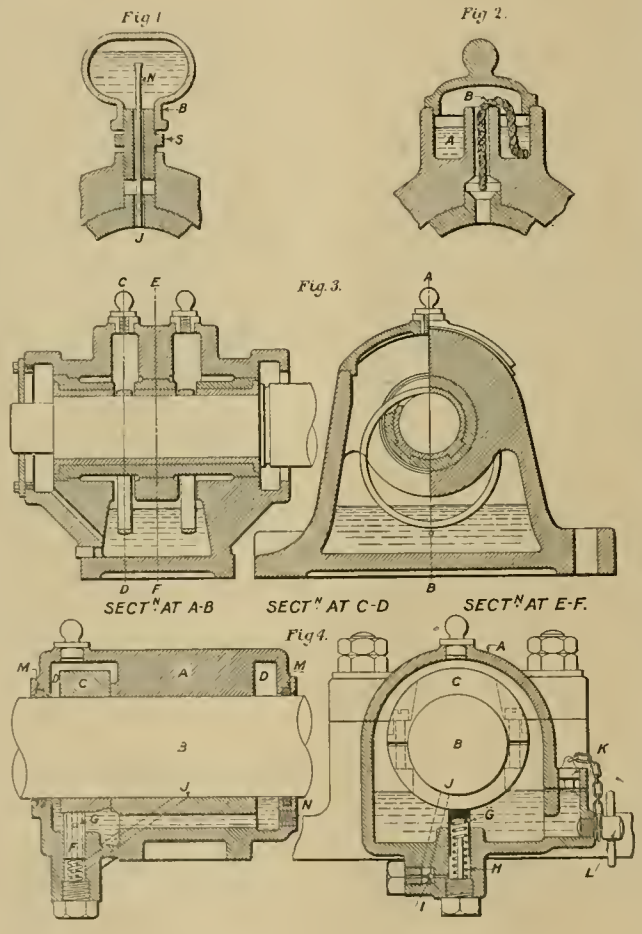
Methods of Lubrication.

Fig. 1 shows an inverted glass reservoir "B," containing a stopper "S," through which passes a needle "N." Under conditions of rest, capillary action prevents the flow of oil past the needle, but when the shaft rotates vibration is set up, and an easy flow of oil takes place. This system is extensively applied in the line shafting of workshop equipment.

In Fig. 2 the syphon system is shown. This system is so well known to marine engineers, and has become so generally adopted in main and auxiliary engines, as to become unnecessary of recapitulation. As the name indicates, the system functions on the syphon principle, and for its success it is essential that the delivery end of the worsted should be below the free surface of the oil in the cup, that no water should be present, and that the worsteds should be kept clean.

Ring lubrication, as shown in Fig. 3, has only a limited sphere of usefulness. One or more rings of a diameter at least twice that of the shaft are suspended from, and rotate by frictional contact with the shaft. Their lower section is immersed in an oil bath and the oil flows over the surface of the journal, through grooves in the bearing, and finally returns to the lower reservoir. This method of lubrication is used in the end or pedestal bearings of electric generators, and is also fairly generally used in electric motors.

Tilston's system of forced lubrication is shown in Fig. 4. An eccentric "C," revolving with the shaft "B," drives a pump plunger "F," consisting of a tube forging with a blind end, and carrying inlet holes "G." A spring "H" keeps the plunger in contact with the eccentric. The oil enters at "G," and in the down stroke of the plunger is compressed, passes through the non-return ball valve "I," and enters the bearing at "J." This system, or one or other of its modifications, is almost universally used on the turbine rotor, thrust and reduction gearing bearings and reduction gearing meshing surfaces, and on the bearings of high-speed auxiliary and Diesel engines. The pressure on the main line is regulated by a relief valve, and varies from 5 lb. per square inch upwards, according to the nature of the requirements. Branch lines connect the main line to the various bearings, and after usage the oil passes to a common sump, from which it is drawn, thoroughly purified, filtered, and again used.



Methods of Natural and Forced Lubrication.

Geared Turbine Lubrication.

In many steamers fitted with double-reduction geared turbines, in which the lubrication is such a vital factor, the gravity pressure system of lubrication finds considerable favour. Gravity tanks are fitted in the engine room at a height commensurate with the pressure desired, which is usually in the region of 10 lb. per square inch. These tanks are supplied by lubricating pumps, and are provided with a safety alarm float system. Should the oil in the tanks fall below the safety level the descending float makes electrical contact, bringing a red light into action, and causing a bell to operate in the vicinity of the starting platform. Unless the oil level in the tank can be immediately raised, following the alarm, the engine should be at once shut down, or irreparable damage may result, as there is generally only an oil supply available in the tank for a period of about five minutes after the bell operates.

The pumps delivering oil to the gravity tanks are generally provided in duplicate or triplicate in case of emergency, and the return line from each bearing is provided with conveniently arranged sight glasses or, alternatively, open-ended pipes, by means of which the oil flow is under constant observation. It is most important that the alarm system should be proved workable prior to the commencement of each voyage, as it frequently occurs that the engineer on watch does not immediately observe the stoppage of a lubricating pump. In one

case coming directly under our observation extensive damage was caused to the H.P. and L.P. turbine blading on a vessel fitted with cross-compound turbines of the Parsons' type. Owing to an interruption in the oil supply the white metal in the thrust pads of both turbines ran, through overheating. Both rotors immediately worked aft under the steam pressure, and the safety collar at the after end of the rotor spindle burned a groove $\frac{3}{16}$-in. deep in the after rotor bearing cast-iron shell, completely destroying the axial blade clearances, and stripping several stages in the H.P. At the inquiry afterwards held it developed that the lubricating pump had stopped, and the alarm had failed to function. Such incidents are fortunately of rare occurrence, but they serve to demonstrate the importance of constant attention and the periodical testing of the alarm system.

Diesel Engine Lubrication.

Reversal of pressure, a factor which simplifies considerably the lubrication of a double-acting steam engine, is absent in the single-acting Diesel engine, and in the latter type of engine forced lubrication in one form or other has come to be generally accepted, and may even be said to be essential for successful running. In the system of forced lubrication most commonly met with in these engines the oil is fed to the main bearings through the centre of the crankshaft. A radial hole in the shaft coincides with an annular recess in the bearing metal, and communication is also established between the crank pin and the interior of the main shaft. From the crank pin the oil is conveyed to the gudgeon either through a hole drilled in the connecting rod or via an external pipe.

In engines fitted with forced lubrication the bearing clearances should be reduced to a minimum, and the artistic designs of oilways cut in the bearing surface under conditions of natural lubrication should be totally dispensed with as these only serve to reduce the useful surface. Professor Reynolds has shown that for conditions of ideal working the two surfaces of a bearing and a journal should converge in the direction of motion permitting the lubricant to assume a wedge formation. On this principle the Michell thrust bearing has been designed, and a comparison between the old-time thrust block, with sometimes as many as 12 collars in vessels of moderate power, and the single collar thrust block, which in H.M.S. *Hood* carries the thrust of 30,000 s.h.p., will serve to indicate the great part which scientific design plays in the practice of lubrication.

The earlier Diesel-engined ships built in the period immediately preceding the war were fitted with natural lubrication, and in two of these ex-German vessels—the *Wotan* and *Loki*—which were recently reconditioned in this country, this system of lubrication was a constant source of trouble. These vessels were fitted with two-cycle engines, and the following extracts from a report on the maiden voyage of the sister vessel *Hagen*, from Hamburg to New York, in the early summer of 1914, are of some interest :—

(1) The speed of revolution of the main motors is high (130 r.p.m.) for large marine engines without forced lubrication.

(2) The crank pin bearings and main bearings are inclined to give trouble which is further aggravated by the piston-cooling water leaking from the swivel pipes and washing out the lubricant.

(3) The consumption of lubricating oil for the engine bearings is abnormal.

(4) After the first voyage to America the main bearings were found, on examination, to have worn down 0·16 in. This abnormal wear was due to want of sufficient lubricant in the bottom halves; this has been improved by introducing oil to the bottom bearings at a pressure derived from a static head of about 5 to 6 lb. per square inch.

General Characteristics.

The infinite variety of physical, chemical, and mechanical tests used as aids to the selection of a lubricant for any specific purpose are of comparatively little value to the practical engineer, whose knowledge of lubricants is, in general, confined to their performance on service. For lubricating oils the average specification includes :—

(*a*) Specific gravity.
(*b*) Closed flash point.
(*c*) Open flash point.
(*d*) Viscosity.
(*e*) Acidity.

Strangely enough two further characteristics of an oil, and of considerable importance, are seldom included in a specification, and these are :—

(*a*) Immunity from sulphur compounds.
(*b*) Description of colour.

It is not possible within the compass of this article to enter into a detailed description of the apparatus and the method of obtaining flash point and viscosity. The flash point (closed) may be defined as that temperature at which the vapour from a substance will ignite in a closed vessel of definite dimensions and design, and the flash point (open) is that temperature at which the vapour will ignite when the cover of the same apparatus has been removed. The apparatus is simple, and the operation is such as may be carried out by any practical engineer with reasonably accurate results.

Viscosity may be defined as the resistance of any substance to a change of shape, and the apparatus most generally used in this country is the Redwood viscometer. With this apparatus, then, the viscosity of an oil is defined as the number of seconds taken for 50 c.cms. of the oil to flow from the viscometer under standard conditions at a given temperature. The flash point of an oil cannot be regarded as any criterion of its value as a lubricant, and this item of a specification is more the concern of insurance companies than that of the engineer. Viscosity is important in the selection of a lubricant for any specific purpose, and the temperature coefficient of viscosity—*i.e.*, the decrease in viscosity per unit rise in temperature—has a direct bearing on the suitability of any lubricant for a given temperature range. For all purposes the proportion of acid in a lubricant should be the minimum possible.

Special Conditions.

In the lubrication of air compressors the tendency of the lubricant to carbonise is an objectionable feature causing constant trouble with the valves. The determination of the most suitable oil—*i.e.*, the oil least likely to carbonise—for any specific compressor is particularly difficult to arrive at in the laboratory, and is more the cumulative result of extended observation under working conditions. The lubricant should be free from acidity, as considerable corrosion has been observed in intercooler coils due to the presence of organic acids formed by the oxidation of the lubricant. For compressors only mineral oils of the highest quality should be used, with a viscosity of 120 Redwood seconds at 140° Fahr., and 52 seconds at 200° Fahr.

The value of graphite as a lubricant has been the subject of much discussion, but its application should be attended with great care, and due regard for the particular circumstances. Beneficial results have been observed by the addition of graphite to certain mineral oils, and in the case of an overheated bearing and scored journal its application has been found to reduce friction. For this latter purpose its use should be strictly limited or choking of the oil passages will result, with disastrous consequences. Some engineers claim that for the lubrication of cylinders its effect is good in that it closes up blow-holes and local irregularities in the cylinder liners, but here again its use should be limited or binding of the piston rings in their grooves will obviously arise.

Saponification.

In marine engines the intensity of bearing loads is, in average practice, about 500 lb. per square inch on the crank pin,

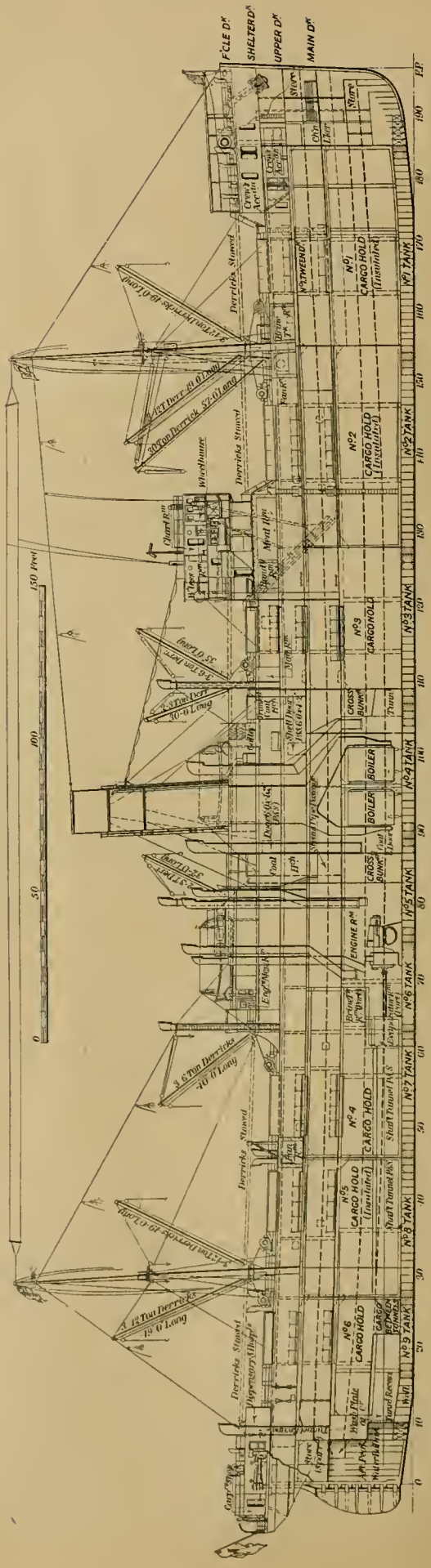
250 lb. on the main bearings, and 1,000 lb. per square inch on the crosshead pins. Owing to the unavoidable presence of water through leaky glands, condensation, &c., it is important that marine engine lubricants should emulsify when water is added, and with this in view marine bearing oils are compounded with a proportion of rape or blown rape oil. A suitable viscosity for these oils is about 3,000 Redwood seconds at 60° Fahr. Turbine oils which, under working conditions, assume a temperature of about 160° Fahr., should have a viscosity of about 1,000 Redwood seconds at 60° Fahr., and 100 Redwood seconds at 140° Fahr. Castor oil has been found to give excellent results on account of its great durability. Standard castor oil has a viscosity of about 6,000 Redwood seconds at 60° Fahr., and 320 Redwood seconds at 140° Fahr. Vegetable and fatty oils should be avoided where there is any possibility of their gaining access to the boiler.

Ball Bearings.

Having regard to the recent far-reaching improvements in the design of ball and roller bearings, there are those who to-day recommend their application to the heaviest marine and high-speed engines. It is claimed, and established, that these bearings reduce friction, and it is popularly, although erroneously, believed by many engineers that no lubrication is necessary. Under conditions of heavy load considerable deformation takes place in the balls and friction is undoubtedly set up between the rubbing points. Mineral grease has been found to give the best lubricating results, and calls for the least attention. The failure of one or more balls in a heavy bearing, and the resultant damage caused, together with the difficulty of replacement at short notice, have to be considered, and it appears unlikely that this type of bearing will find any extended application in heavy marine work where reliability is a paramount consideration.

In conclusion, it may be said that the only reliable means of arriving at the suitability of a lubricant for any specific purpose is by prolonged observation under working conditions, and by a close analysis of results. However great care may be taken in the choice of a lubricant, unless cleanliness and intelligence are exercised on the part of the engineer, the best results will never be achieved.

Engineering Conference.—The Secretary of the Engineering and National Employers' Federations issued on June 16: "The Engineering and National Employers' Federations and the National Union of Foundry Workers met in conference on June 14, 15 and 16, 1922. Joint recommendations were arrived at in connection with the questions of overtime, nightshift and systems of payment by results, and these will be submitted forthwith to the constituent bodies on both sides for ratification." The Engineering and the National Employers' Federations issued the following statement on June 20: "The Boilermakers and Iron and Steel Shipbuilders' Society have now agreed on behalf of their members affected by the recent dispute in the engineering and allied industries to accept the terms agreed upon between the Engineering and the National Employers' Federations and the other trade unions concerned on June 2, 1922. The dispute is, therefore, now terminated, and employment is available to the members of all the trade unions. It will be remembered that of the 50 or more unions involved in the managerial rights dispute, agreement was reached with all except the Boilermakers' Union, which returned an adverse majority in the recent ballot. It was not anticipated, however, in view of the general settlement, that the boilermakers would long maintain their attitude of isolation. Now that the lock-out is completely lifted, the industry, it is expected, will quickly recover." A conference convened to discuss wages reductions has been postponed.


FCLE D.K
SHELTER D.K
UPPER D.K
MAIN D.K
No 1 CARGO HOLD (Insulated)
No 2 CARGO HOLD (Insulated)
No 3 CARGO HOLD
No 4 CARGO HOLD
No 5 CARGO HOLD (Insulated)
No 6 CARGO HOLD
No 7 CARGO HOLD (Insulated)
No 1 TANK
No 2 TANK
No 3 TANK
No 4 TANK
No 5 TANK
No 6 TANK
No 7 TANK
No 8 TANK
No 9 TANK
BOILER
BOILER
ENGINE R.M.
Derricks Stowed
Windlass
Capstan
Steering Engine
Mast
Funnel
Shaft Tunnel
Cross Bunker
Coal Bunker
Fresh Water Tank
Engine Room
Boiler Room
Cargo Hold
Between Decks
Upper Deck
Main Deck
Shelter Deck
Forecastle Deck
Poop
Bridge

NEW SHAW, SAVILL & ALBION TWIN-SCREW LINER "MATAKANA" OF 18,620 TONS DISPLACEMENT.

Built and engined by Alexander Stephen & Sons Limited, Linthouse, Glasgow, and fitted with Brown-Curtis Turbines and Double-Reduction Gears.

We publish this month some interesting particulars and drawings of the Shaw, Savill & Albion twin-screw liner, "Matakana" which was recently completed by the builders at Glasgow. The "Matakana" performed a highly successful maiden voyage from the United Kingdom to New Zealand, via the Panama Canal, and homewards to London, via Cape Horn. This voyage was one of 80 days and the total distance steamed works out at about 30,000 miles. The average speed for the voyage was 12¼ knots and the vessel is now completing her second voyage. The vessel is of the shelter-deck type, with complete steel upper and main decks. There are four main 'tween decks and four holds insulated for the carriage of frozen meat. An insulated chamber is provided for ship's use, and the entire refrigerating machinery is by J. & E. Hall Limited, of Dartford, working on the CO_2 system. Two main holds and 'tween decks, together with the shelter-deck space, are designed for the carriage of general cargo.

The following is a list of the more important dimensions of the vessel :—

Length between perpendiculars	477 ft. 0 in.
Breadth, moulded	62 ft. 9 in.
Depth moulded to upper deck	34 ft. 4 in.
Depth moulded to shelter deck	42 ft. 10 in.
Block coefficient to load draught	·762
Deadweight, including bunkers	11,000 tons.
Gross tonnage	8,047·73 tons.
Nett tonnage	5,030·02 tons.
Displacement, loaded	18,620 tons.
Draught, loaded	28 ft. 8¼ in.
Horse-power	5,000
Sea Speed	12¼ knots.

On the trial trip over the measured mile at Skelmorlie a maximum speed of 15 knots at 90 r.p.m. was attained.

Propelling Machinery.

The main propelling machinery, as will be seen from the plate drawings included with this issue, consists of two sets of Brown-Curtis turbines, each set having one high-pressure and one intermediate-pressure turbine coupled in tandem, and one low-pressure turbine driving the propeller shafts through an improved system of double-reduction mechanical gearing. Separate steam pipes are provided to enable each set to work independently, and exhausts are led to "Uniflux" condensers underslung on the low-pressure turbines. The turbines are coupled to the gear pinions by special flexible couplings and are capable of developing a collective shaft-horse-power of 4,500 when driving the propeller shafts at about 82 r.p.m. The high-pressure and intermediate-pressure turbines have a speed of about 3,500 and the low-pressure about 2,300 r.p.m. when developing this power.

Astern turbines are fitted, the high-pressure astern being incorporated in the same casing as the intermediate ahead turbine, and the low-pressure astern in the low-pressure ahead exhaust casing. The astern turbines together are capable of developing not less than 60 per cent. of the total ahead power. To suit the superheated steam conditions, the high-pressure ahead turbine casings and the high-pressure astern nozzle boxes are of cast steel. The turbine blading is of the latest Brown-Curtis type, of phosphor-bronze and of combined section, having the packing piece solid with the blades. Each turbine is fitted with an Aspinall patent governor and forced lubrication control, working in conjunction with Cockburn-McNicoll patent emergency bulkhead valves.

Double-Reduction Gearing.

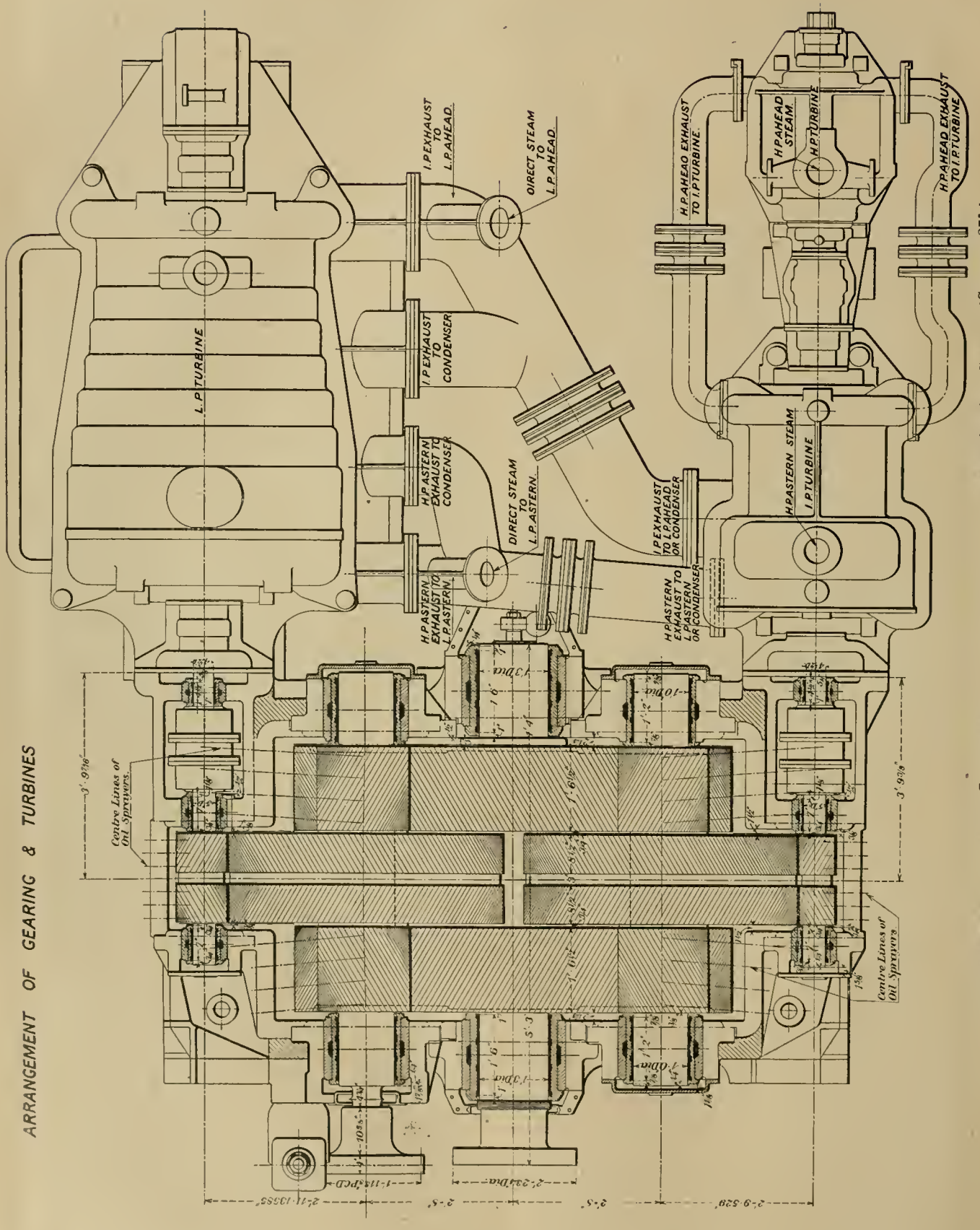
On page 272, we produce a drawing showing the assembled arrangement of turbines and gearing. In the manufacture of this gearing the wheel rims have been made from high tensile steel and the wheel pinions from high tensile nickel steel. These gears were cut in accordance with the latest and most approved method by the builders. At the conclusion of the vessel's maiden voyage, the gearing was opened up for inspection at London, and was found to be in first-class condition. It is worthy of mention, at a time like the present, when the performance of double-reduction gearing is the subject of much discussion, that, in addition to the gearing in the *Matakana*, the builders have also cut single-reduction gearing for 12 of H.M. destroyers and double-reduction gearing for 14 merchant vessels. The results obtained with each type of gearing have been of the most satisfactory nature, the majority having stood the test of long voyages. We show on page 262 part of the gear-cutting plant engaged on a large helical gear wheel at the works of Alexander Stephen & Sons Ltd. The large gear hobbing machine is by Muir & Melloy, of Manchester, and is capable of cutting a full range of gears from 3 in. up to 12 ft. diam. Among other special features, the machine is fitted with a patent creeping table which causes the work to creep with reference to the main dividing wheel, thereby eliminating any inherent errors of the dividing wheels.

Boilers and Auxiliary Machinery.

The boiler equipment consists of two double-ended and two single-ended Scotch multitubular boilers. The former are 14 ft. 7½ in. diam. by 21 ft. 6 in. long, and the latter are of equal diameter, but are 12 ft. 6 in. in length. All boilers are fitted with smoke-box superheaters, capable of providing a superheat of 200° Fahr. A working pressure of 220 lbs. per square inch has been adopted, and ample grate and heating surfaces are incorporated for the requisite power. These boilers work under Howden's well-known system of forced draught.

A very fine installation of auxiliary machinery has been provided, comprising two dual air pumps, one "Monotype" auxiliary condenser air pump, one hotwell pump, two main feed pumps, two bilge pumps, one sanitary pump, two general service pumps, and two forced lubrication pumps, all by G. & J. Weir, of Cathcart, Glasgow. The main and auxiliary condenser circulating pumps are by Drysdale, of Glasgow, and the ballast, fresh water and refrigrator circulating pumps are by Lamont, of Paisley. A Weir direct-contact feed water heater, two Caird & Rayner evaporators, one Railton & Campbell's lime-feed filter and a Kirkaldy water distiller are also fitted. The oil coolers are to the design of the builders, the forced draught fans and engines are by James Howden & Co., of Glasgow, and the ash hoist is of Crompton's manufacture.

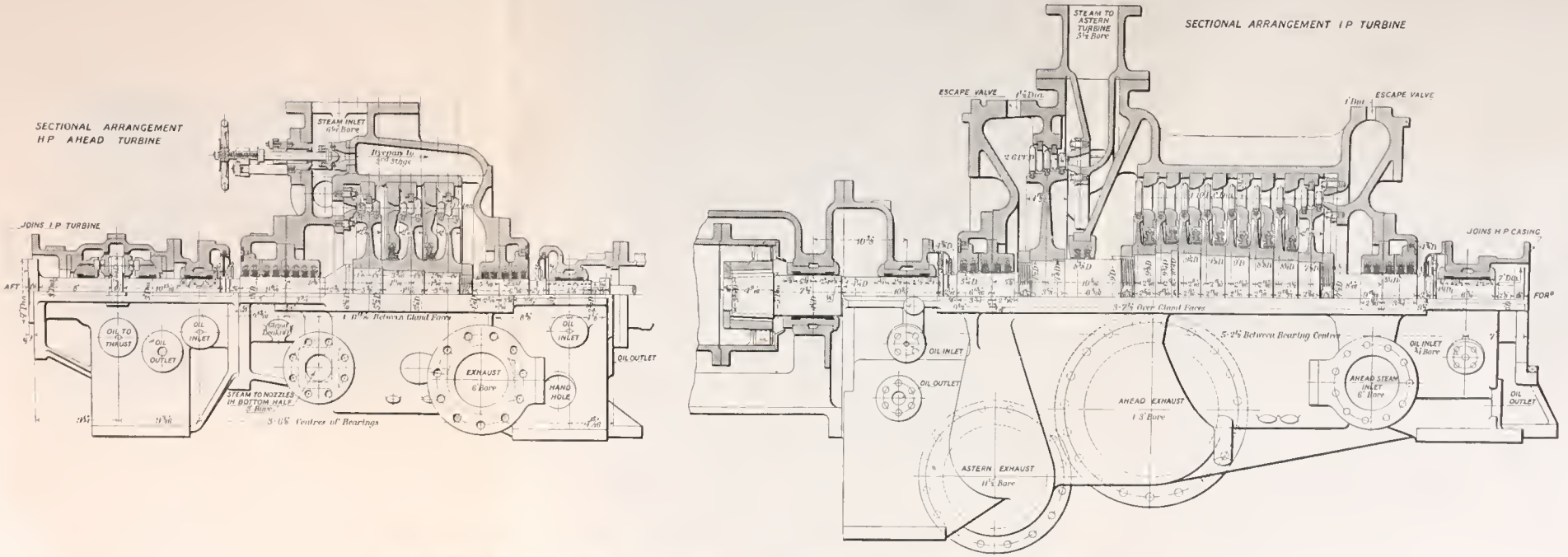
The boilers and machinery have been manufactured throughout in accordance with the highest requirements of Lloyd's Register of Shipping.


L.P. TURBINE
I.P. EXHAUST TO L.P. AHEAD
DIRECT STEAM TO L.P. AHEAD
I.P. EXHAUST TO CONDENSER
H.P. ASTERN EXHAUST TO CONDENSER
DIRECT STEAM TO L.P. ASTERN
H.P. ASTERN EXHAUST TO L.P. ASTERN
I.P. EXHAUST TO L.P. AHEAD OR CONDENSER
H.P. ASTERN EXHAUST TO L.P. ASTERN OR CONDENSER
H.P. AHEAD EXHAUST TO I.P. TURBINE
H.P. AHEAD STEAM
H.P. TURBINE
H.P. ASTERN STEAM
I.P. TURBINE
H.P. AHEAD EXHAUST TO I.P. TURBINE
Centre Lines of Oil Sprayers
Centre Lines of Oil Sprayers

SS. "Matakana."—General Arrangement of Turbines and Double-Reduction Gears. (See page 271.)

T.S.S. "MATAKANA."

Sectional Arrangements of Brown-Curtis H.P., I.P., and L.P. Turbines, built by Alexander Stephen & Sons, Linthouse, Glasgow.



THE SCIENTIFIC CONTROL OF COMBUSTION.

Some Features of the "W.R." CO_2 Recorder—Early Experiments—Application to Oil-Burning Passenger Tonnage.

At a time like the present, when the world's ports are congested with laid-up tonnage which cannot be operated on a remunerative basis, anything tending to reduce the cost of running ships will be as welcome as it is necessary. The shipowner agrees that the two heaviest items in his operating charges are fuel and repairs. In the careful selection and training of his engineering personnel the owner has, to a great extent, the control and partial elimination of repairs within his power, but in the realms of fuel consumption he is, more or less, the victim of existing practice, and only to a very limited extent is it possible so to educate a boiler room staff that the efficient combustion of fuel is at all times under strict observation.

The first essential in arriving at perfect combustion is that the proportion of CO_2 present in the flue gases should be continuously known, and while a great number of instruments—many of them extremely complex—have been devised from time to time, the majority of these have not met with any extended commercial application and their use has in most cases been discontinued after a brief period. In several ships which we have known it has been by no means uncommon to observe at night time a 6-ft. column of flame surmounting the funnel top, and so imperfect was the engineer's comprehension of the essentials of combustion that this condition was regarded as desirable, inasmuch as it was believed to furnish unmistakable evidence to the master of the ship that no effort was being spared by the engineer to ensure that the voyage should be completed with the minimum of delay. Happily the question is viewed with more enlightenment to-day, and, with the high costs of fuel ruling, great savings can be effected by controlling combustion on scientific lines.

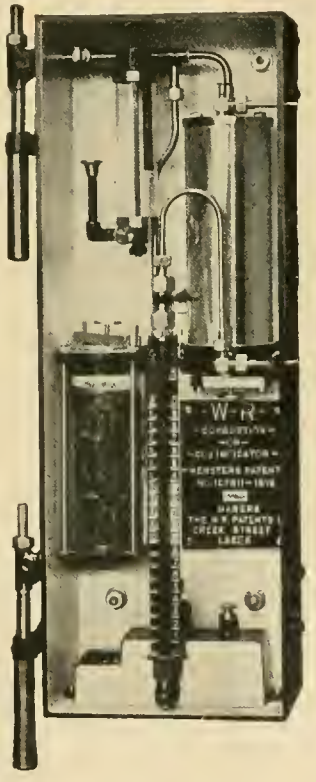


Fig. 1.—"W.R." CO_2 Indicator.

In the course of experimenting with porous pots fitted with a rubber cork, through which passes one leg of a manometer tube containing coloured liquid (the difference in level of which, in the two legs, indicates the difference in pressure between the inside and outside of the pot), it was invariably found that the presence of any material inside the pot capable of absorbing moisture gave a persistent vacuum. On investigation it was also found that the amount of vacuum produced depended entirely on the amount of moisture in the air. An experimental demonstration gives the clue to an entirely new principle of gas analysis. Inside such a pot is placed a paper cartridge containing calcium chloride, which, of course, absorbs moisture. If the cork be replaced tightly a slight vacuum will in due course be produced, and this will vary with the amount of moisture in the air. There is thus obtained a very simple instrument which shows the amount of moisture in the air continuously. The CO_2 apparatus consists of a porous pot, inside which is placed a paper cartridge containing granules of soda lime. The lid is replaced and screwed down tightly. The whole unit is then placed inside a testing-box, into which can be put varying quantities of carbon dioxide from the gas cylinder, and the tube coupled up in connection with the inside of the pot to the manometer. After mixing the gas in the chamber a vacuum is gradually formed. A certain definite height of liquid will be given for definite percentages of CO_2, and the accuracy of the measurement of CO_2 by this appliance, even in a crude form, is within $\frac{1}{2}$ per cent. To utilise this simple experiment for practical purposes, all that is necessary is to aspirate continuously a sample of flue gas to the chamber containing the porous pot which automatically measures and indicates at any instant the percentage of CO_2 surrounding it. The quickness or responsiveness of the indication depends solely on the porosity of the pot, which can be varied indefinitely. This phenomenon of obtaining a vacuum in a porous pot containing a suitable absorbent, when enveloped by an atmosphere containing a gas which is being absorbed, and the fact that the amount of such vacuum depends solely on the percentage of absorbable gas surrounding the pot, are entirely new.

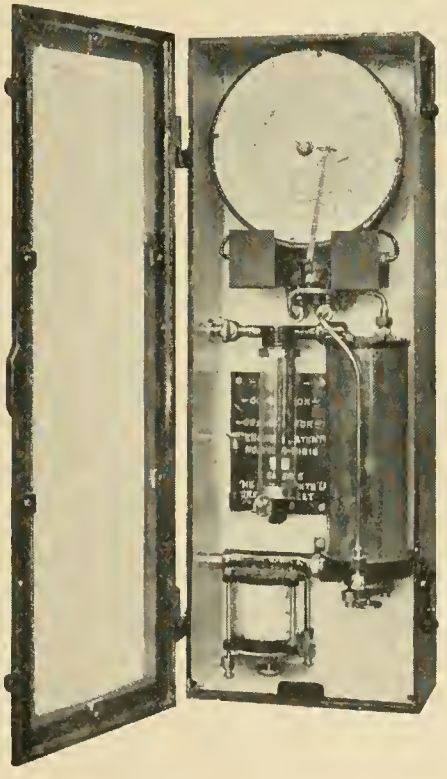


Fig. 2.—Self-Contained CO_2 Recorder.

The foregoing represents briefly the principle on which the W.R. CO_2 indicator functions and this instrument is shown in Fig. 1. The action of the indicator will be more readily understood by reference to the diagram shown in Fig. 4. An aspirator S is fixed at a point as near the base of the uptake as possible and continually aspirates gases from the flue. The path of the gases is shown by arrows. These gases are first drawn through the filter F and pass thence into the chamber containing the porous pot P, inside which is the dry reagent R. Water contained in the vessel B indicates the flow of gas by continual bubbling. A pipe connects the chamber with a vessel containing water into which dips one end of another pipe G, the other end of which is taken to the inside of the porous pot. As soon as absorption commences a vacuum is produced and the percentage of CO_2 is read direct from the gauge. Fig. 3 shows a combined indicator and

recorder which gives a gauge glass reading and also a chart reading, while Fig. 2 shows a self-contained recorder.

Having regard to the high initial temperature of the flue gases and to the possibility of condensation in the pipe lines to the indicator it is important that these pipes should be arranged with a gradient to assist in the drainage of any condensation. The range on the indicator between 9 and 14 per cent. is marked in red to indicate the levels between which the liquid should be kept. Practically the only attention required by this apparatus is the renewal of the absorbent cartridge once every 24 hours. The average of 12 to 13 per cent. CO_2 may be considered to represent conditions of good combustion and under these conditions it is claimed that a fuel economy of as much as 15 per cent. has been achieved. Among the better known ships which have been fitted with this CO_2 recorder are the *Aquitania, Mauretania, Berengaria, Scythia, Samaria, Metagama, Empress of France, Empress of Scotland, Empress of Australia*, &c. The apparatus is manufactured by the W.R. Patents, Limited, 17, Greek Street, Leeds.

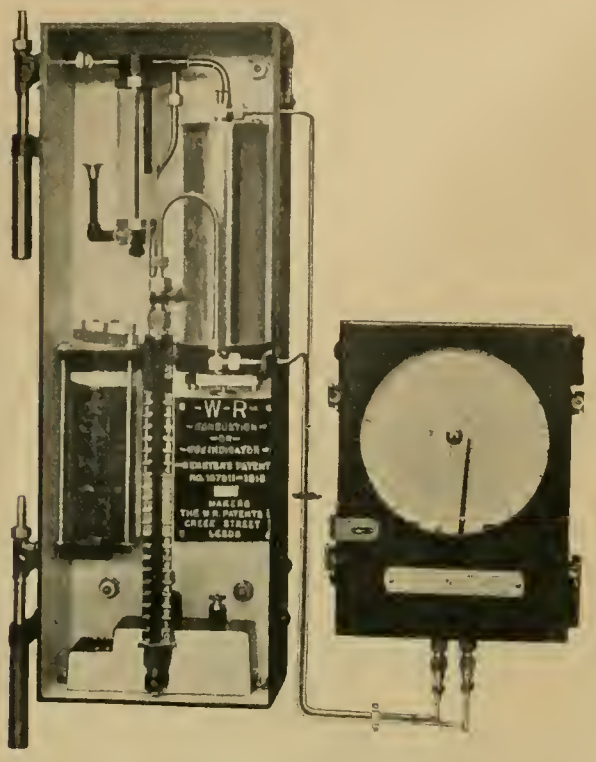


Fig. 3.—Combined Indicator and Recorder.

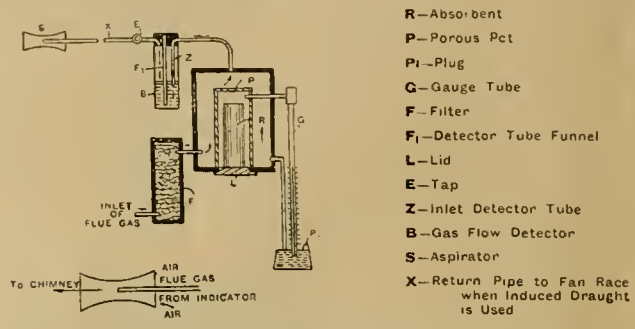


Fig. 4.—Diagram showing Principle on which "W.R." CO_2 Indicator Functions.

CLEAN WATER AND MARINE BOILERS.

Scotch *versus* Water-tube Boilers on Atlantic Service—Elimination of Impurities from Feed Water—Importance of Distilled Water for Water-tube Boilers.

During the coming months the very large passenger liners on the North-Atlantic service should yield some exceedingly interesting results regarding boiler performance. Now that the *Aquitania* and *Mauretania* with their big cylindrical boilers have been converted to use liquid fuel, and the German-built *Berengaria* and *Majestic*, with their three-drum type water-tube boilers are also to be employed on the same route, valuable comparative information should shortly be available as to the relative service experience of the two types of steam generator. All four ships, as is well known, were originally designed to burn coal and all have been converted to oil. Very little data, indeed, has been made public regarding the actual horse-power, the steam production, and the fuel consumption of any of these vessels, and it will be some little time before any really definite evidence regarding the respective performances under the new conditions can be expected. What, however, is of particular interest at the present time is the fact that, *at last*—we advisedly emphasise the point—the water-tube boiler has gained admission into an ocean service on which all British owners have hitherto resolutely declined to adopt it, and that not without its advantages having repeatedly been urged. It is very doubtful, indeed, whether the water-tube boiler would have been fitted even by now if it had not been for the fact that it was contained in surrendered vessels, and oil-fuel was introduced rather on account of recent difficulties in supply and price of coal than on its own merits as a marine fuel—merits, too, which are now well proven to have been worth somewhat greater consideration in previous years.

Cylindrical *versus* Water-tube Boilers.

The saving in weight of machinery rendered possible by the use of water-tube in lieu of cylindrical boilers is so great that this satisfactory performance on a particularly hard-worked service may not unlikely lead to a much more extended application of the type, particularly when associated with oil-fuel, with far reaching effects on the design of vessels of this class, so that more than ordinary interest will be displayed in the result. It is not since the Cunard Company put the *Caronia* and *Carmania* in service in 1905, in order to test the relative merits of reciprocating engines and turbines, that such an opportunity has been presented for observing on the largest scale the comparative performance of so important an element in marine steam engineering.

In spite of the universal use of water-tube boilers in warships, and of their adoption to the extent of perhaps four to five million horse-power in mercantile vessels, for large ocean-going vessels they have, with a few exceptions, been almost entirely ignored. How has it happened that with the mass of satisfactory evidence in their favour, superintendent engineers have been reluctant to fit them? In spite of the very considerable saving in weight and ample proof of their economy in

service, their use in the merchant service has been largely restricted to special cases such as channel steamers, in which the saving in weight cannot be ignored because it forms such a distinct fraction of the displacement of the ship, or vessels whose service routes render them dependent on very inferior fuel for which large grate areas are indispensable. One factor of considerable importance has undoubtedly been the adverse and lasting impression created by the widely advertised difficulties with certain types of long-discarded boilers when the change from the cylindrical type was made in the Royal Navy over 20 years ago. Realisation of the improvements made and the high standard of reliability since attained seems to have hardly overcome the original doubt as to whether trouble and the water-tube type were not synonymous terms.

But there are two more cogent factors than prejudice which have operated against the wider use of the lighter boiler. The first has been the anticipated difficulty of securing proper results with firemen used to cylindrical boiler furnaces. With coal-fuel, the large grate of a water-tube boiler needs to be fired lightly and frequently, and not heavily and seldom, as with cylindrical furnaces. Firemen have never been an easy problem, and their behaviour, except in disciplined forces, cannot be guaranteed. With the mechanical firing of oil this practical objection to exposing a good article to bad use is entirely eliminated, and the question resolves itself less into a matter of what in actual practice can be got out of the boilers with the disposable staff in the stokehold than into a pure question of boiler efficiency and durability in service. In many ways, the separate cylindrical furnaces with their warm air draught possessed marked advantages over the single large grate of the water-tube boiler, but with oil this vanishes, and complete constancy of conditions of operation has entirely supplanted the continual rise and fall of furnace temperature due to firing and cleaning fires, admission of excess air through open doors, &c.

Importance of Distilled Water.

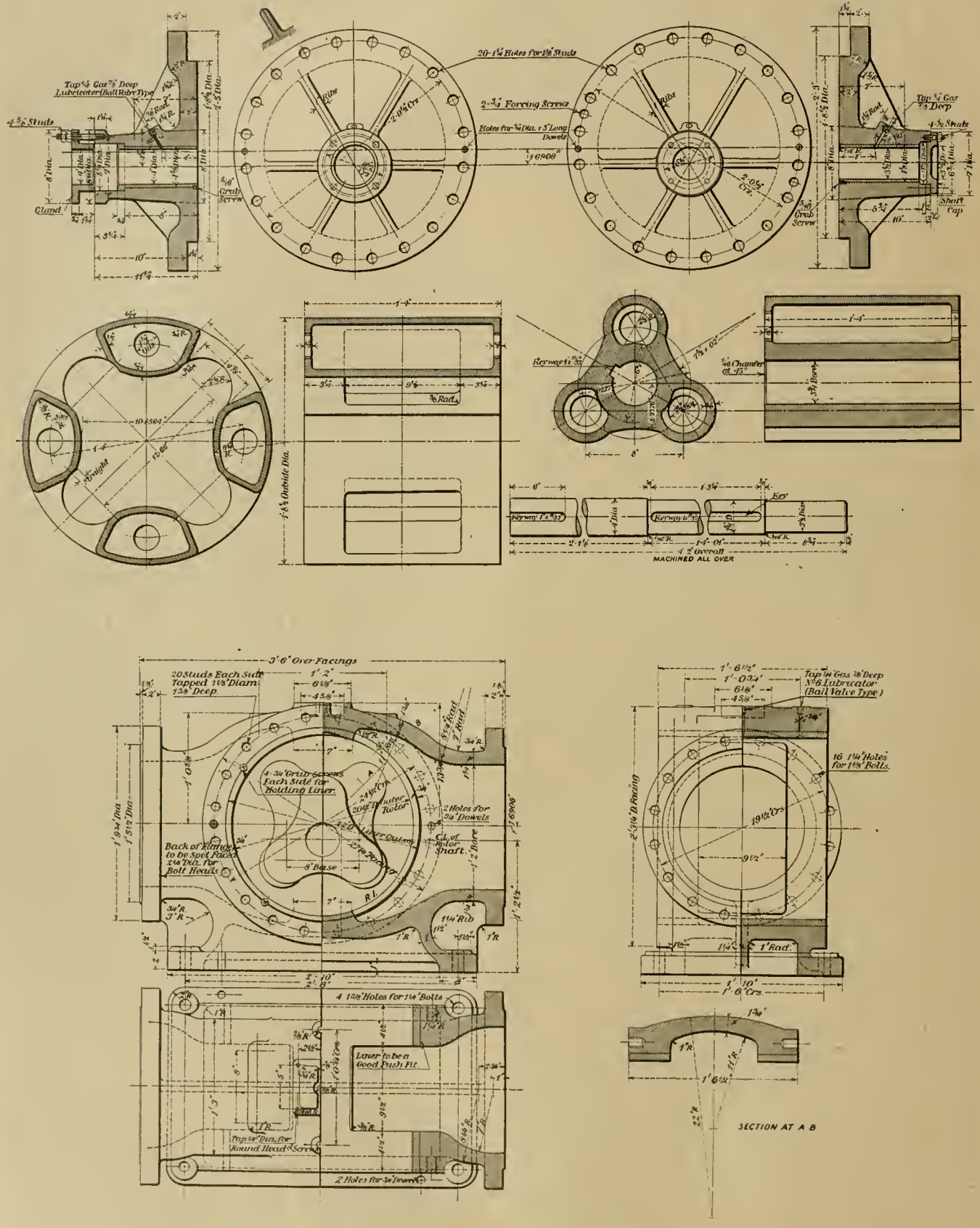
The second reason, which was widely advanced against the water-tube boiler in the merchant service, was the fear of corrosion if salt water was admitted, and the objection to the installation of distilling plant for the purpose of making up the feed water. With water-tube boilers there is no doubt whatever that care must be observed with the feed water. It is not sufficient merely to use "fresh" water and trust to its approximating to "pure" water, as a river or town supply may contain quite indefensible quantities of matter for use in boilers. Dock water is most undesirable; it may not contain as much salt as sea water, but it is usually extremely dirty. Many a good water-tube boiler has been ruined simply by inattention to the fundamental necessity of using sufficient care with the feed water. It is not easy to exaggerate the importance of carefully testing the quality both of the feed and of the water in the boiler at frequent and regular intervals when water-tube boilers are fitted, but it is far from correct to assume that this may be ignored to a greater extent with cylindrical boilers. Better results must follow from clean alkaline water in the boilers than from those in which the chlorine element is in any way aggravated. It is a very difficult matter to prevent any sea water at all getting into the boilers, but if it do so to excess, corrosion, due to the action of the hydrochloric acid liberated when salt water gets into contact with heated steel, will be set up independent of the type of boiler.

Methods of Detecting Impurities.

In some vessels an electrical indicator, working on the principle that the cleaner the water and the freer from salt the less current it will pass, is used to warn the engineer on watch that the quality of water is beginning to require attention. Salt, air and oil all require to be kept out of boilers as far as possible, and the best means of prevention or of nullifying the effect of the former at least are perfectly well known. It is the lack of observance of this, either in the original design of machinery or in the operation at sea, that is responsible for troubles arising. As regards the two latter causes of corrosion modern practice has gone very far to eliminate the effects for which they used to be responsible. The closing of the entire system to the air, the trapping of means of escape of any air, and better design and supervision of glands and condenser tightness have largely suppressed this, the usual cause of trouble in main and auxiliary turbine sets, while the more elaborate filtration of the feed and other developments have prevented the older troubles with oil. Salt, however, will leak in to some extent, and the best preventative is tight condenser tube ends with the use of milk of lime to neutralise the effect, and of carbonate of soda to keep the water in a safely alkaline condition. Distilled water only should be used for feed make-up. Provided that these precautions are properly observed there should be no difficulty with the interior of the boiler, and in this connection it is interesting to learn that the scheme for installing a large distilling plant at Southampton for feed water supply is making good progress. It is often a great temptation to use dock-side water supplies and in very many cases it is perfectly justifiable to do so, but there are a number of exceptions in which it is not—in several continental ports for instance—and no little trouble has occasionally been experienced with water-tube boilers in not ascertaining the quality of water taken on board *before* it finds its way into the system. In the case of the vessels we have mentioned there should be no doubt that these all-important points are receiving attention; the water-tube boiler, therefore, on the North Atlantic should receive a very fair trial and there can be few who do not believe that it will prove entirely satisfactory.

John Brown & Co. Limited.—The report for the year ended March 31 states that the serious diminution of orders, mentioned in the last report, has been intensified during the past 12 months, and all departments of the company's business have been acutely affected. Important contracts have been suspended owing to the high wages payable, and any return to normal trade has been greatly hampered by the same conditions, coupled with serious labour troubles. The net profit for the year, including refund of excess profits duty, after charging debenture and loan interest, depreciation on plant and machinery, and provision for income tax, amounted to £210,407, compared with £331,920 for the previous 12 months. The sum of £179,599 was brought in, making a total of £390,006. The directors recommend a final dividend of 2½ per cent. on the ordinary shares, making 5 per cent. for the year, compared with 10 per cent. for the previous 12 months, leaving £180,631 to be carried forward.

International Mercantile Marine.—According to the Central News, the report of the International Mercantile Marine for the year ended December 31 last shows that the net earnings amounted to $14,070,000, against $17,480,000 for the previous year. The Surplus amounts to $5,798,000, as compared with $9,905,000 last year. The report states that the outlook for 1922 is far from encouraging, and it is estimated that the results for the first five months will show a marked decrease as compared with the same period in 1921. The immigration law is said to be responsible for the decreased business.

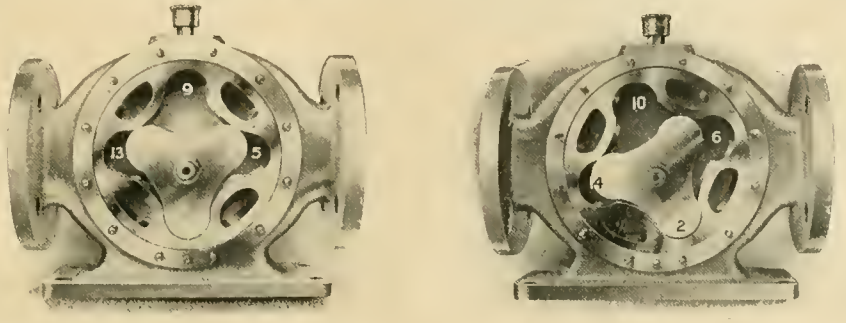

20-1¼ Holes for 1⅛ Studs
2-¾ Forcing Screws
Holes for ¾ Dia. x 3" Long Dowels
Tap ¼ Gas ⅞ Deep Lubricator (Ball Valve Type)
4-⅝ Studs
Gland
Ribs
Tap ¼ Gas ⅞ Deep
4-⅝ Studs
Shaft Cap
⅝ Grub Screw
Keyway ⅜" Wide
⅛ Chamfer at 45°
Key
MACHINED ALL OVER
3'-6" Over Facings
20 Studs Each Side Tapped 1⅛ Diam. 1⅜ Deep
4-¾ Grub Screws Each Side for Holding Liner
20 Outer Rotor
2 Holes for ¾ Dowels
Ctr. of Rotor Shaft
Back of Flanges to be Spot Faced 2⅛ Dia. for Bolt Heads
1¼ Rib
4 1⅜ Holes for 1⅛ Bolts
Liner to be a Good Push Fit
Tap ⅛ Dia. for Round Head Screw
2 Holes for ⅜ Dowels
16 1¼ Holes for 1⅛ Bolts
Tap ⅛ Gas ⅜ Deep ⅜ Lubricator (Ball Valve Type)
SECTION AT A B

Constructional Features of Type 8 × 16 Feuerheerd's Rotary Pump. *(See opposite page.)*

ROTARY PUMPS FOR MARINE SERVICE.

A Valveless Pump for Marine Work—Tests on Heavy Mexican Oil—Special Features of Design.

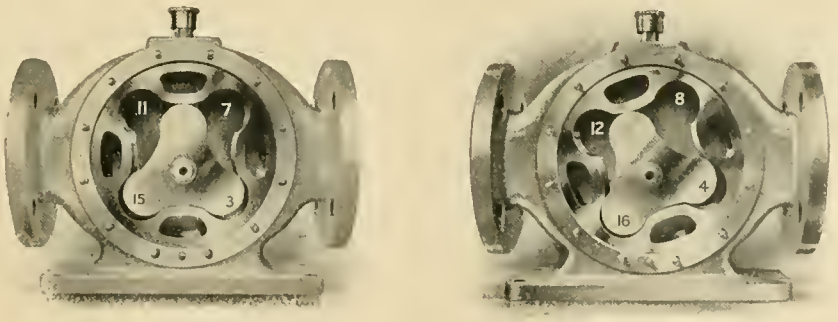
Within the last few years the efforts of pump designers have been directed towards the production of a pump which will overcome to a great extent several of the inherent disadvantages of pumps of the reciprocating type. Among such disadvantages may be mentioned the heavy windage or churning effect due to the large idle clearance spaces, excessive inertia of moving parts with resultant wear and backlash in the bearings, and the serious wire-drawing losses in forcing a fluid through a complex valve chamber. One such pump which has overcome these disadvantages without a corresponding efficiency drop is the Feuerheerd's patent rotary pump manufactured by Stothert & Pitt Ltd., of Bath. This pump has been found to be specially suitable for the complex pumping duties associated with sea service, and highly successful results have been obtained on work of this nature.



Stage 1. Stage 2.

Cycle of operations, first two stages.

By way of illustrating the principle on which this rotary pump functions, we produce a series of four views showing the exposed mechanism of the unit with the cover removed. The essential parts of this pump are the main body and covers, an inner rotor keyed to the driving shaft, and an outer rotor which rotates under the influence of the inner rotor. The outer rotor is concentric with the main body within which it revolves as an easy working fit and all end play is prevented by the two body covers. These rotors are arranged with their centres off-set as shown, and the inner rotor is restrained in its proper relative position by the driving shaft bearings. Stages 1, 2, 3 and 4 show the cycle of operations during one complete revolution. In Stage 1 the projection 1 of the inner rotor completely fills a recess in the outer rotor, and by following the ascending numbers in the successive Stages 2, 3 and 4, the path of this projection will be seen. During one revolution the projection moves forward to the next recess, simultaneously creating a pocket of gradually increasing capacity up to the position 9 in Stage 1. From this point onwards to 16, Stage 4, the capacity is gradually reduced until the pocket is again filled by the next projection, as in 1, Stage 1.



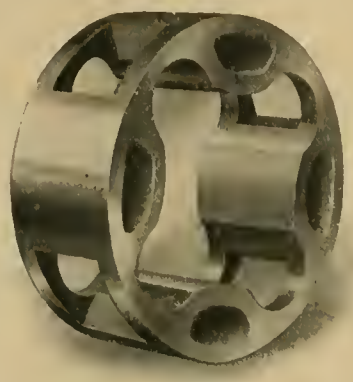
Stage 3. Stage 4.

Third and fourth stages, completing the cycle.

Suction of the fluid to the pump is created through the ports of the outer rotor, separately illustrated, while the pocket is increasing in volume and is ejected at the opposite side of the pump when the pocket is decreasing during the last half revolution. From the separate illustration of the outer rotor, it will be seen that this has four ports which are open to the chamber of both the suction and delivery sides of the pump during rotation. Cut-off between the suction and delivery of the pump is effected by means of a lip at top and bottom of the main body which momentarily closes these ports. The main body in these illustrations is, for purposes of simplicity, shown without a body liner. Body liners are fitted in all cases with the exception of the very small sizes of pump. The complete absence of valves and the fact that there are only two moving parts in this pump, are features of considerable practical value.

These pumps are in general use to-day on board ship, and are used for such a wide range of duty as oil-fuel transfer, forced lubrication, oil and water cooling, hot and cold water, sanitary and ballast services. From the nature of its design this pump has proved itself particularly suited to the pumping of all manner of fuel oils, and with the rapidly increasing use of oil as a fuel, both for steam raising and in the Diesel engine, its application on board ship is likely to be considerably extended. On page 279 we illustrate a type 8 × 16 pump on the test bed at Bath undergoing efficiency trials. For test purposes the drive was arranged by means of an electric motor through double helical reduction gearing with an overhung motor pinion and wheel. It is only comparatively recently that reliable data relating to all types of pump engaged on the pumping of oil has become available which would be of appreciable assistance to engineers, both for the purpose of securing a pump suitable for a specific duty and also as a check on the economical working of the pump when installed. We produce on the next page two graphs showing the results obtained from the type 8 × 16 pump at outputs of 300 and 150 tons per hour respectively, running at the corresponding revolutions of 200 and 100 per minute. These tests were carried out with Mexican fuel oil of a standard specific gravity of ·95. The different viscosities corresponding to the temperatures given are shown on the graphs, together with the corresponding pressures and b.h.p. required. In the case of the first graph it will be seen that, with fuel at a temperature of 82° F. and a discharge pressure of 100 lbs./in.², an overall efficiency of 75 per cent. was reached. In Diesel-engined vessels the most convenient method of driving these

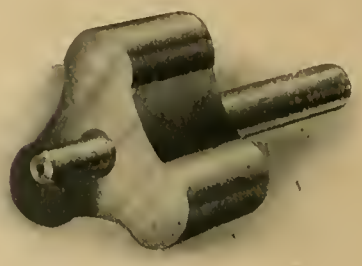
pumps is by means of an electric motor and reduction gearing. On page 279 we illustrate an alternative method of application adopted in an oil-tanker, which comprises a vertical, high-speed Belliss & Morcom steam engine with a standard 8 × 16 pump. The table below the figure gives the dimensions and characteristics for three sizes of pump with the arrangement as illustrated. The engine shown is compound and develops 125 b.h.p. at 525 r.p.m. with a steam pressure of 160 lb./in.² Single reduction, machine-cut helical gearing is provided, and the pinion and shaft are cut from the solid. Engine and pump are assembled on a common bed-plate, making a compact unit, and as there is invariably ample headroom in an oil-tanker, this feature presents no difficulties. Suction and delivery pipes to this pump are 14 in. in diameter, and are adapted for British standard flanges. For condensing and non-condensing working respectively, the following are the guaranteed steam consumptions (within 5 per cent. test margin) per b.h.p. per hour when supplied with dry steam at the engine throttle valve, and, in the case of condensing, with 25 in. vacuum :—



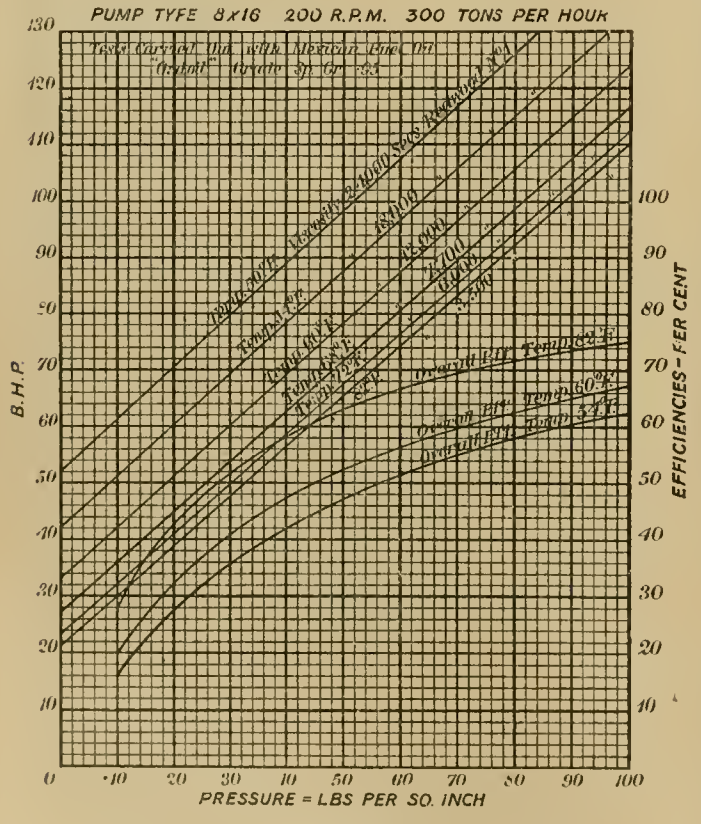
Outer and Inner Pump Rotors.

Steam pressure.	Condensing.	Non-condensing.
160–180 lbs./in.²	20·3 lbs.	25·2 lbs.
100–120 „	22·4 „	28·0 „

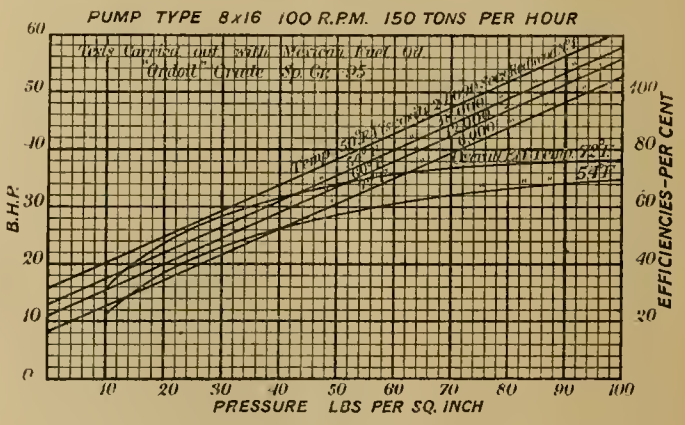
In addition to the electrically and steam-driven sets already described, several portable, petrol-driven units have been used with success for bunkering ships. One such unit is a pump of 27 tons/hour capacity, working at a delivery pressure of about 38 lb./in.², and driven by a 9 b.h.p. standard "Lister" engine. This unit is the property of the Scottish Oils Limited and is in use on the Clyde for bunkering purposes. The pump is mounted on a railway wagon equipped with flexible hose and is run from wharf to wharf as occasion demands. We give below some particulars of tests carried out on this special Feuerheerd pump by the Scottish Oils Limited in March of this year. The petrol consumption worked out at 0·8 pints per b.h.p./hour.



	First Test. (1 Rail Car).	Second Test. (3 Rail Cars.)
Duration of test	26 minutes.	1 hour 24 minutes.
Length of 3½-in. bore suction hose in use	1 at 15 ft.	2 at 30 ft., 1 at 15 ft. Total equals 75 ft.
Length of 5-in. bore discharge hose in use	60 ft.	60 ft.
Total head (static)	33 ft.	33 ft.
Average speed of pump	376 r.p.m.	359 r.p.m.
Quantity of oil pumped	12 tons 9 cwt. 1 qr.	36 tons 11 cwt. 0 qr.
Specific gravity of oil pumped	·869.	·869.
Flash point of oil pumped	226° F.	226° F.
Quantity of oil pumped *per hour*	28 tons 15 cwt. 0 qr. 21 lb.	26 tons 2 cwt.



Test Results at 300 tons per hour Output.



Test Results at 150 tons per hour Output.

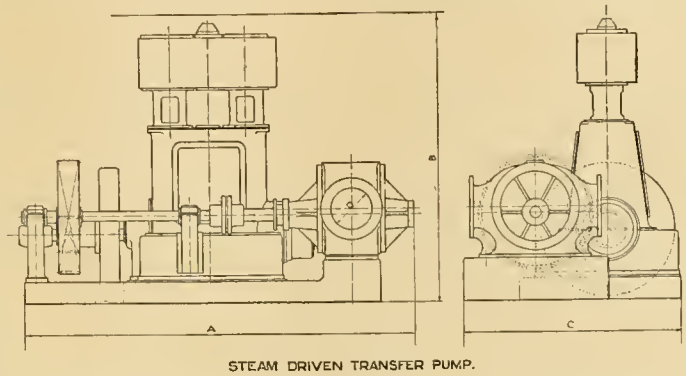
On page 276 we produce a series of line drawings illustrating the more outstanding constructional features of the later Type 8 × 16 Feuerheerd's Rotary Pump. As will be observed from the drawing, a ¾-in. liner is interposed between the periphery of the outer rotor and the inner surface of the main body. The cut-off lip between the suction and delivery of the pump, situated at the top and bottom of the main body, will be seen, and the very substantial nature of the design and construction of these pumps will be readily evident.

Several of the more viscous fluids have been pumped successfully by these pumps, including tar, molasses, bitumens, &c. About twelve months ago the United States Shipping Board were engaged on the shipment of heavy creosote from London to America. This creosote, which had a specific gravity in excess of unity, was brought alongside the ship in barges and, owing to the disadvantages attending the deposit of the heavy solids in suspension, the creosote had to be rapidly transferred from

the barges to the vessel while hot. A very large suction head was involved, the ship's pumps were at a disadvantage and a special type 4-in. Feuerheerd's pump was acquired for the purpose. This pump was driven by a D.C. 8 h.p. electric motor through single-reduction gearing, power being supplied from the ship's electric generator. The pump and motor complete were placed on the fo'c'sle head of the barge, and the total working head was 35 ft. The performance of this set exceeded the highest expectations and the output was greater than that guaranteed by the makers.

Special fluids demand special features of design and material, but as a general rule, for oil pumps, it may be said that the pump body and covers are made from close-grained cast iron. The body liner and the inner and outer rotors are manufactured from special hard cast iron.

The modern tendency in the development of Diesel-engined tonnage is towards the elimination of the donkey boiler and the substitution of the all-electric drive for deck and engine-room auxiliaries. Engineers are agreed that by this means the highest overall economy can be attained. The compact design of this pump, and the facility with which it may be adapted for conditions of electric drive, render it particularly suitable for Diesel tonnage, and several vessels of this type have already been so fitted.



STEAM DRIVEN TRANSFER PUMP.

PUMP TYPE	TONS PER HOUR	PUMP SPEED R.P.M.	PRESSURE LBS PER SQ IN	B.H.P.	A	B	C	D
8 × 16	300.	200	90	125	10-4	8-1½	5-6	14
10 × 20	450.	150.	118	200 – 220	12-3	9-0	6-9	15
12 × 24	600.	117.	82	200 – 220	12-9	9-0	7-0	16

High Speed Belliss & Morcom Steam Engine driving Feuerheerd's Rotary Pump through Single-Reduction Gearing.

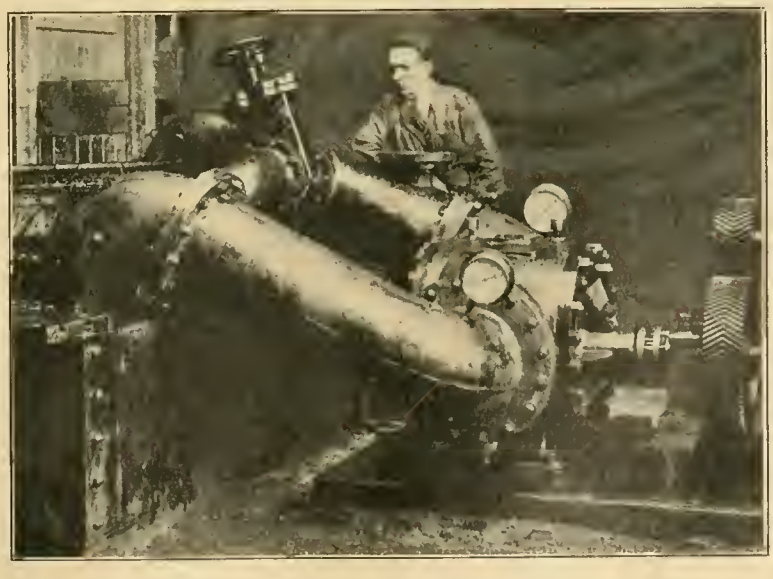
BOILER AND PIPE-COVERING TESTS.

Some interesting information has been published recently in connection with tests carried out with slag wool used for covering boilers and steam pipes. Two of the most efficient materials in use for this purpose are slag wool (made by blowing steam into molten blast-furnace slag, and consisting of a mass of fine fibres of silicate, somewhat resembling wool in appearance) and 85 per cent. magnesia (85 per cent. hydrated magnesium carbonate and 15 per cent. asbestos fibre). The tendency in land practice is to buy cheap and shoddy coverings, which are the worst possible investment, and it can be stated without exaggeration that 5 per cent. of the coal used for steam generation on land throughout the world is wasted in condensation losses because of the use of inferior coverings. In marine practice much better attention is given to this question, but still further economies are, in average practice, certainly possible.

Slag wool has one advantage over magnesia in that it will stand almost any temperature, even several thousand degrees, whereas magnesia cannot be used for over 700 deg. Fahr., as just above this temperature the hydrated magnesium carbonate begins to calcine and is thus no longer a non-conductor. The tendency, of course, is to use higher and higher steam pressures and temperatures of superheated steam, and the figure on land to-day in power station practice is 200 lb. pressure and 650 deg. Fahr. steam temperature, and it is quite likely that before long steam temperatures of 700 to 900 deg. Fahr. will be in use on an extensive scale.

The efficiency of slag wool is about 96 per cent. under average conditions, using 2½ in. thickness—that is to say, 96 per cent. of the condensation loss in a bare pipe is prevented. The corresponding figure with 85 per cent. magnesia is about 84 to 89 per cent., so that there is little difference in actual efficiency between the two coverings. A very specialised combination for the highest pressures and temperatures is 1-in. slag wool next to the pipes, followed by 1½ to 2 in. of 85 per cent. magnesia, the whole finished off with ½-in. hard-setting composition as a binder. One disadvantage of slag wool is that, if used alone, it must be finished off with the more expensive sheet metal covering, so as to be maintained in position close to the pipes.

A general source of fuel wastage, on land especially, is uncovered steam pipe flanges. There is no need for this to-day with modern detachable flange boxes, as, if the joint blows, all that is necessary is to detach the flange box in a few seconds and refill it with the non-conducting composition.



Type 8 × 16 Feuerheerd's Pump Under Test on Heavy Mexican Oil.

BRITISH TRADE SHIP.—In view of recent announcements of a projected voyage round the world by the steamship *Orontes*, renamed *British Trade*, confusion has arisen between this voyage and that arranged for another vessel under the auspices of British Trade Ship Limited, of which Earl Grey is chairman. Earl Grey and his co-directors of British Trade Ship Limited, desire to make it quite clear to intending exhibitors on the *Orontes* (or *British Trade*) that British Trade Ship Limited, is in no way responsible for any arrangements in connection with the *Orontes* voyage.

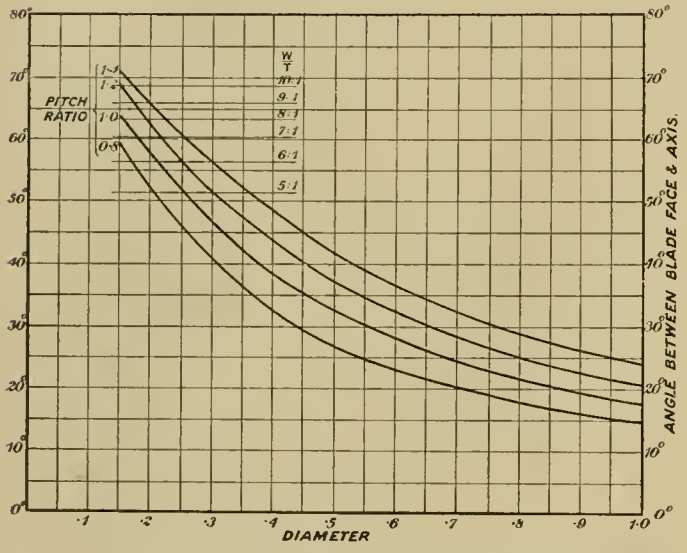
THE RAKE OF PROPELLER SHAFTS.

Factors which influence Shaft Rake.—Effect of Rake on Propeller Efficiency—Vertical and Horizontal Angles.

The principle of slightly raking propeller shafts in the vertieal or horizontal planes besides having much to recommend it, is often inevitable and may be said to be either advisable or necessary for the following reasons: the former in order to suit the intended form of ship, which really means the choice of suitable propeller position at one end of the shaft and the convenience of machinery installation at the other, while as regards the latter, the necessary clearance between hull and propeller blade tips, plus the half diameter of the propeller to the shaft axis, may enforee an outboard bearing centre which leaves the designer no option but to install a shaft angle greater than that whieh would otherwise be acceptable.

Earlier Practice.

There is no doubt that in many recent cases of high-powered



Curves showing Angle between Propeller Blade Face and Shaft Axis.

twin-screw torpedo boat destroyers the shape of stern of ship, the propeller diameter necessary to absorb 22,000 s.h.p. per screw, and the fact that the use of single-reduction gear wheels involves a high shaft centre in the engine room have all combined to enforce very steep shaft angles. In single-screw vessels, wherein the after-shaft centre is settled by the propeller diameter, and the distance of its tip above the keel line, the only object in departing from the horizontal is to reduce the height of shaft tunnel in the case of reciprocating engines, or to admit of automatic cylinder drainage in the case of turbines, but in the case of twin, triple and quadruple-screw vessels, both vertical and lateral divergence may become a matter of considerable importance. For instance, with triple shafts and direct-connected turbines it was usual to adopt centre lines parallel with that of the ship, and to allow only such vertical inclination as would clear the turbines of water, whereas with triple shafts and reciprocating engines a very considerable divergence of outer shafts has generally been necessary in order to avoid the overlapping of the several propeller discs. With twin-screws and reciprocating engines little or no difficulty has usually been experienced in seleeting suitable positions of screw from the point of view of hull efficiency, tip clearance and flow of water past bossing or brackets, and of machinery without the use of angles exceeding one or two degrees, but the inerease in power per shaft which we have recently witnessed has had the effect of increasing these amounts to a marked extent, particularly as regards the vertical angle.

Propeller-Blade Angles.

If, for the moment, we consider propeller-blade angles, without reference to shaft angles, we shall be able to obtain a better idea of the absolute values involved first, and will subsequently be able to form a clearer mental comparison of what the effect of shaft rake will be. We give opposite, for the various percentages of diameter for screws of various pitch, ratio curves showing the actual angle which the propeller-blade face makes with the axis of the shaft. The angle at which this blade face meets the water depends, of course, on the real slip. If the section of the blade near the boss is actually parabolic and symmetrical on each side of the radial centre line, the angle between the front and back surface at the edge of the blade can be calculated directly from the tangent, and thus for various ratios of eircumferential width of blade (W) to thickness at centre line (T) we find—

W/T	=	5	6	7	8	9	10
Angle between face and back at edge of blade	=	38·63°	33·75°	29·75°	26·5°	24°	21·75°

The horizontal W/T lines on the diagram show the points beyond whieh the sum of the blade-face angle, plus blade-edge thickness angle, exeeeds 90°, so that if the (blade-face angle) + (slip angle + blade-thickness angle) exceed 90°. the angle formed by the tangent to the back surfaee on the trailing edge and the line of progression will be *negative* to the extent of this excess. On page 281 we show how this occurs by representing a thin modern destroyer propeller and the propeller of the late Hamburg-America Atlantic liner *Deutschland*. Both sections are shown at one-third of the screw's radius, and the centre line is taken as parallel with that of the ship. Now, the horizontal divergence is generally very small, and only in a few extreme cases of twin-screw turbine-driven torpedo craft in which separate engine rooms have been placed fore and aft do we find the angle between shaft and ship as much as 1·5°

Tendency of Vertical Rake.

Vertical rake, however, has been greatly increased in recent years. When the direct-connected turbine was first installed in torpedo craft, very high revolutions and small diameter screws and small overall diameters of turbine cylinders were the rule, and little inclination was needed. Thus, in the "Tribal" class, the angle between shaft and water line was about 2·7° on the centre and 3·7° on the wing shafts, and in the succeeding class—the "Beagles," also with triple screws—it was only about 2·0°. In the later twin-screw designs, when the propeller and turbine diameters were increased roughly in the ration of $\frac{\sqrt{3}}{\sqrt{3}}$, the engine-room centre rose and the screw axis had to drop, with the result that angles of 3°-3·5° rapidly increased to 4°, 4·5° and even to 5° when the main turbines were placed side by side, but when, as in the German torpedo craft, where the standard engine-room arrangement consisted of the starboard turbine in one room forward, and the port turbine in a separate one aft, the short shaft-length of the latter forced up the angle of descent considerably, and in successive pre-war years the port and starboard angles became 4·3° and 2·1°, 5·4° and 2·3°, 5·7° and 2·7° respectively, the horizontal divergence totalling 3° between the two shafts, or

1·5° each. In several British vessels the vertical angle had approached 4°; in the case of the "V" class destroyers it was 4·6°, and in the "Mackay" class it amounted to about 5°, or as much as 1 in. per foot. In the U.S.S. *Pruitt*, whose thrust trials have frequently been compared with those of the latter ship, the vertical angle was only 2·56°.

Variation of Pitch.

Tank trials of series of model screws made for ascertaining basis performances are, of course, conducted with the shaft axis in the line of progression. But when the axis is already set at 5° to the horizontal when the vessel is at rest (and the ship may trim perhaps 2 in. in 6 ft. or between 8 ft. and 9 ft. in her 300 odd ft. of length) the screw proportions begin to differ considerably in their relation to the actual line of progression. Take, *e.g.*, the "Mackay's" propeller of 10 ft. 6 in. diameter and 12 ft. 6 in. pitch; P/D = 1·19, with a vertical rake of 5°. When a given blade is on the top centre or on the bottom centre, and in these two positions only, the blade-face angles in relation to the line of advance are the same as if the shaft were horizontal. Now let the screw be moved round 90°. In this position, the rake has the effect of *increasing* the face angle at each radius by a constant amount—5° in this case: at 270° the same amount must be *subtracted* from the pitch angles of the ascending blade. As the addition or reduction is constant over the whole blade, it follows that, for the descending blade the pitch becomes, in relation to the actual direction of motion of the screw (for its relation to its axis obviously remains unchanged, except for any possible springing of the blades), an outwardly increasing pitch; for the ascending blade it becomes an outwardly decreasing amount. If for the "Mackay's" propeller at 90 per cent. of the radius we refer to Fig. 1, we find a blade-face angle of 23° with the axis. At 90° and at 270° the angle becomes 28° and 18° respectively, and converted into terms of pitch (at 0·9° of the radius) we have—

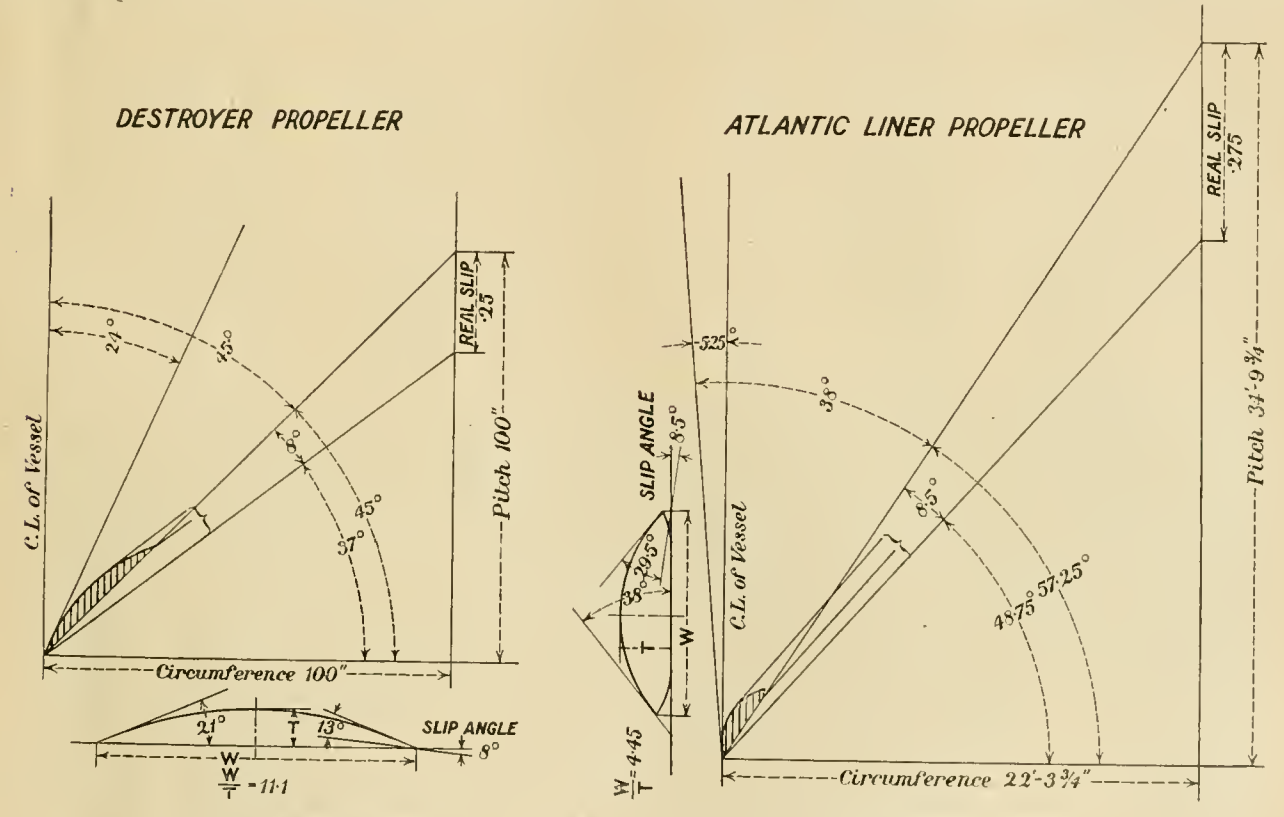
Blade at top centre with face pitch			=	12·6
Blade at 90°	„	„	=	15·9
Blade at 180°	„	„	=	12·6
Blade at 270°	„	„	=	9·6

The normal full-speed revolutions are practically 360 per min., or 6 per sec., so that the variation from normal to maximum takes place in $\frac{1}{24}$th sec. and from maximum to minimum in $\frac{1}{12}$th of a sec. The variation from the normal pitch ratio of 1·19 is from 0·905 to 1·5 at this radius: it varies, of course, with the radius as will be seen from Fig. 1.

Effect of Rake on Performance.

It is interesting to consider what this variation involves: it obviously upsets all calculations of pitch, slip, pressure, &c. The effect is to throw the centre of thrust off the centre of the shaft and the consequence is an increase of bearing pressure in the A bracket bearing. This is essentially a very thoroughly water-cooled bearing (forced lubrication has often been applied to these bearings as the result of experience), and there is no means of knowing how much power is wasted in friction at this point, but it is hard to believe that it is not a very tangible quantity. Taking the figures for Mackay's light-load trial, speed of ship = 35·46 knots, and r.p.m. = 353·4, the pitch limits indicated show a variation in real slip between 0·012 and 0·405.* If the variation of pitch be worked out for the U.S.S. *Pruitt* at the corresponding position on the screw, it will be found that, from the blade-face angle of about 21·3°, the total variation is from 18·7° to 23·9°, compared with 18° to 28° from the 23° of the "Mackay."

However much independent analysts may differ in their own interpretation of the thrust trials of these two vessels as regards the balance between water factor and the corresponding analysis pitch factor taken, all will agree that in relative rotation efficiency the *Pruitt* was markedly superior to the "Mackay." There can be little or no doubt that this extreme rake in the case of the latter must have exercised a very material influence on the performance of the screw for



Comparison between Destroyer and Atlantic Liner Propeller Blade Angles.

* In this connection, the writer in an entirely independent analysis to that of Mr. Frodsham Holt, extracted a much lower (Froude) wake factor for this trial. The above figures follow Mr. Holt's own table using B = ·12 (*i.e.*, not B = 0·925). With the lower wake factor (= 0·035) the real slip at the 270° position is actually about 0·03 *negative*, and about 0·38 at the 90° position.

more reasons than one. A propeller, like many other things, has two faces, and the same addition or subtraction of angle of rake must be made to both sides. The variation of actual pitch (not face pitch) over the blade therefore becomes almost insolubly complex. But there is also one further objection to this extreme rake. The long and heavy A bracket boss presents a considerable projected surface to its line of progression through the water, and passing through it at full speed—some 60 ft. per second—it must obviously render the mass of water into which the propeller enters far less dense than would be the case if the shaft axis and line of progression were more nearly in the same plane. In other words, it largely nullifies the suction action on the back of the blades; it adversely affects the quantity of water which should pass through the screw's disc, and further prevents the projection of a mass of water astern which is part of the proper function of a propeller in obtaining the necessary reaction to drive the ship.

Extreme Rake a Disadvantage.

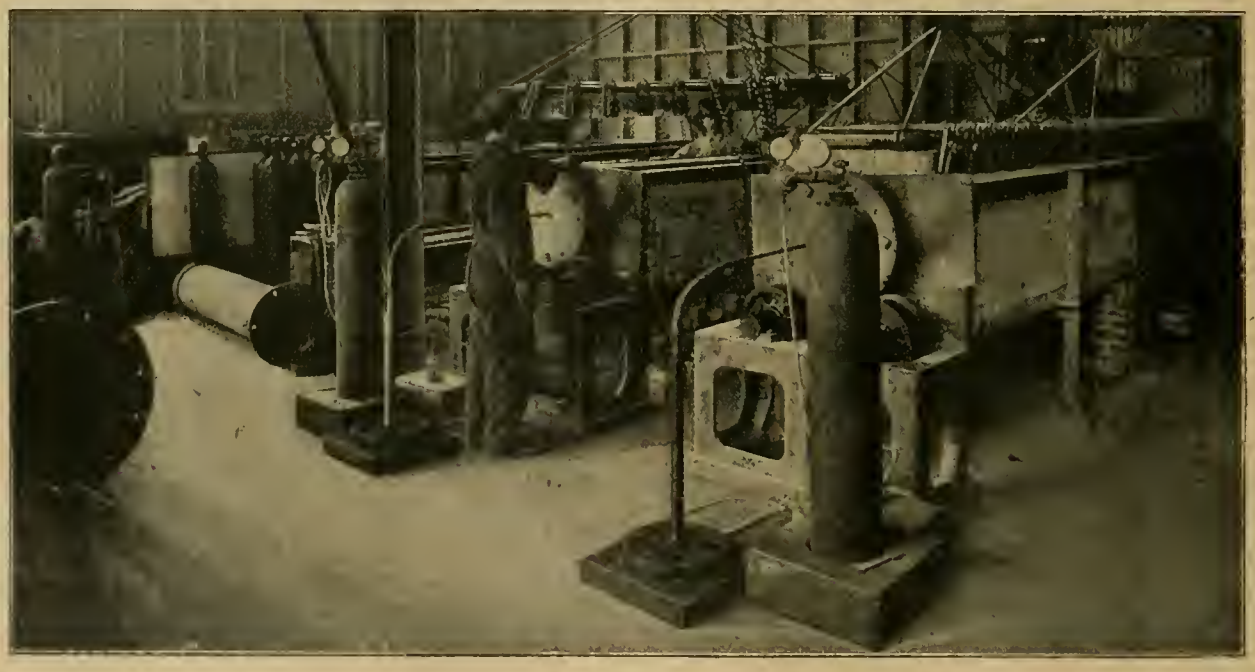
It is, however, impossible to dissociate this particular disadvantage with the design of the ship as a whole. In order to obtain a flow of water more at right angles to the disc of the propeller, such as was actually secured in the case of the *Pruitt*, a considerable modification to the run of the hull would have been required. This was available in the *Pruitt*, the 310 ft. length of which was only 15 ft. less than the "Mackay's," albeit the latter was of 50 per cent. greater displacement. Stability in the *Pruitt* was obtained largely in her length; the weight distribution in "Mackay" demanded a considerable width aft, and no complete comparison of the two vessels is possible without taking these and other factors into account.

THE PROTECTION OF METALS FROM OXIDATION AT HIGH TEMPERATURES.

Advantages in Marine Practice—Extent of Homogeneous Penetration—Application to Condenser and Boiler Tubes—Considerations of Cost.

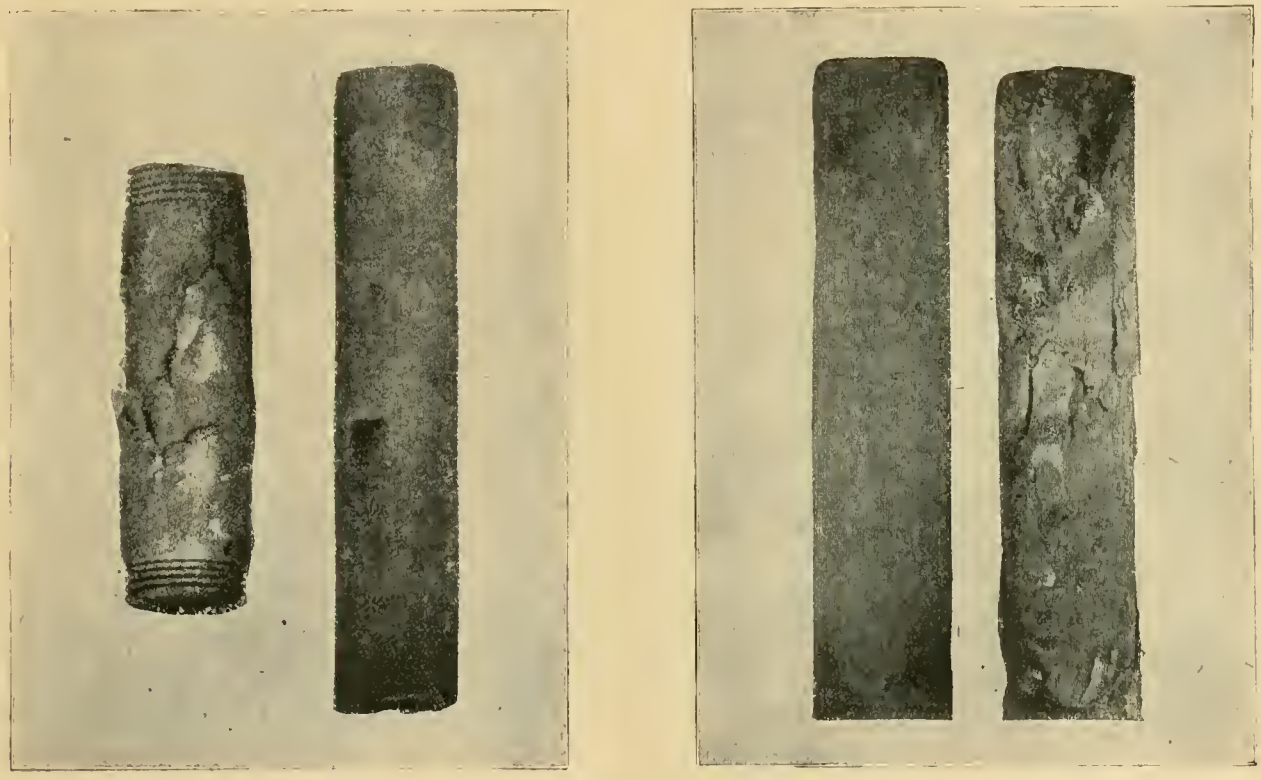
There must be very few engineers, and particularly marine engineers, who have not many times felt the need for a metal which would stand up to the continued contact with high temperatures in service. The frequent renewal of combustion chamber stays and nuts, and boiler tubes and stay-tube nuts exposed to the erosive action of high temperature flame, involves a considerable amount of labour, and adds very appreciably to maintenance costs. In land practice, annealing furnaces, ovens, &c., have usually been composed of iron, but this has been prone to scale badly under the action of repeated high temperatures. Alloys containing nickel, cobalt and chromium will withstand fairly high temperatures, and are more or less permanent in the air at red heat; but the objections of cost, and the difficulty of working for small sections or castings, has retarded their commercial adoption on a large scale.

The very heavy deterioration of their electric heating elements led the General Electric Company to undertake research work, with a view to arriving at a method of protecting these elements against the oxidising influence of high temperatures. After extensive investigation a process known as Calorizing was evolved, and this process was first adopted in 1911. Briefly, the treatment consists of heating metals in stationary or rotary retorts in a reducing atmosphere, with a mixture containing finely divided aluminium. On this page we produce a photograph showing a close view of these retorts.



View showing Calorizing Retorts.

This treatment, conducted at a high temperature, so thoroughly infuses aluminium into the exposed portion of the metal being treated as to form a homogeneous aluminium alloy for a certain depth. This depth ranges from a few thousandths of an inch to the permeation of the entire mass, according to the duration of the treatment. We show on page 284 a photograph from which the extent of the penetration of the alloy into the section of calorized copper rods may be observed. These rods have a diameter of $1\frac{1}{4}$ in., and were calorized for a period of about two hours. The essential point of difference between calorizing and other commercial protective processes is claimed to be that the protective metal is not superimposed as a coating or a skin on the metal to be treated, but, on the contrary, enters into intimate association with it, forming a perfect alloy.



Photographs showing comparison between Calorized and Untreated Tubes.

Calorizing is primarily a protection against burning or scaling, and is not intended to protect against corrosion; but calorized copper, brass or nickel are, nevertheless, excellent non-corrosive elements, being strongly resistant to the acids. In one large power-station considerable trouble was experienced due to the early corrosion of condenser tubes. Guaranteed tubes were found in some cases to fail after being in service for several weeks only. Some few years ago calorized tubes were installed, and it is stated that no further difficulties have been experienced. Railway controller copper contacts have been treated by the calorizing process, and are stated to have given several times the life of untreated contacts.

As evidence of the performance of calorized metal under test conditions, the wrought-iron pipes, shown in the first, or left hand photograph on this page, were cut from the same piece. The longer pipe was calorized, and was afterwards heated to 1,800° Fahr. in an electric furnace, open to the air, and cooled, the operation being repeated several times. The total time during which the maximum temperature was maintained was about 50 hours. Thereafter it was heated to 1,620° Fahr., and plunged into cold water after it had cooled to a dull red heat. This was repeated three times, and the surface showed no signs of cracks or scale. Finally, this piece and the untreated piece were heated side by side with an ordinary blast lamp to a temperature of about 1,700° Fahr. for four hours. Both pieces were cooled, and heat was once more applied for four hours. At the end of this test the untreated pipe was badly burned, and its thickness had been reduced by one-half at the point of application of the flame. The calorized pipe was found to be unchanged. In the second, or right hand photograph the results of a sulphur dioxide test are shown. Two pieces of extra heavy wrought-iron pipe, one calorized, the other uncalorized, were run side by side in a furnace at 1,500° Fahr., in an atmosphere of sulphur dioxide, for a period of four hours. At the end of this time the ordinary pipe was badly burned, as shown, while the calorized pipe appeared in all respects in as good condition as before the test. Two further examples illustrating the comparison are shown on page 284. In the first of these photographs an annealing box is shown. This box was cut in halves, one half was calorized and the other untreated. Both halves were then welded together, and the box as a whole was subjected to a temperature of 1,500° Fahr. for a period of 30 hours, with the result as illustrated. In the last of these photographs a sheet-iron annealing box is shown, and from the cover a small rectangular piece was first removed and calorized. This portion was welded into the cover again, and the whole tested in an annealing oven for two periods of five hours each at 1,500° Fahr.

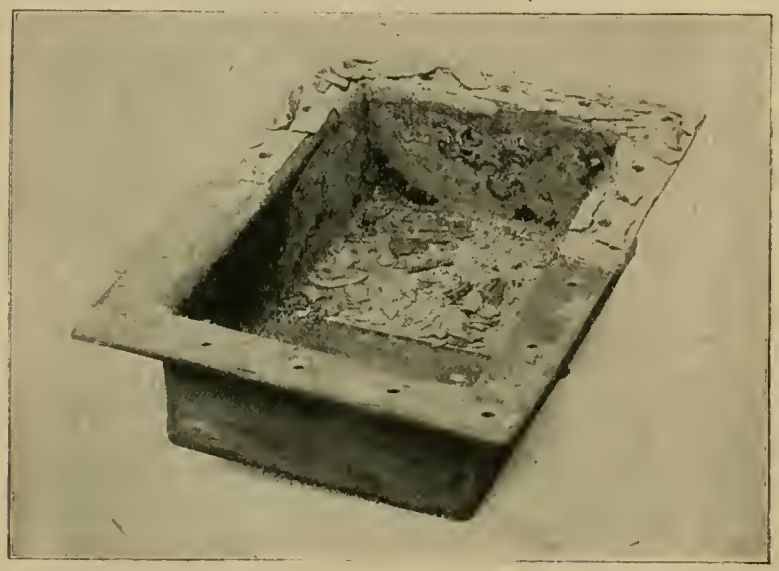
It is of some interest to observe the physical properties of calorized metals under test, and we show overleaf a table giving the results of some tests carried out by the National Tube Company on calorized steel boiler tubing of 2 in. diameter.

These results go to show that the calorizing process anneals the material, giving results which are favourably comparable with those obtained by a soft, annealed finish. From the various investigations carried out it has been proved that calorizing does not injure the metal treated, and that the treated material is capable of withstanding all ordinary handling without destruction of the alloy or calorized portion. It should, however, be understood from the nature of

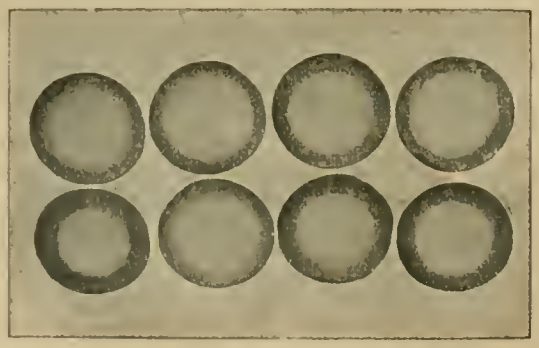
Test No.	Elastic Limit. lb. per sq. in.	Ultimate Strength, lb. per sq. in.	Per cent. Elongation 2 in.	Per cent. Elongation 8 in.	Per cent. Reduction
1	29,660	47,150*	—	—	51·6
2	28,750	45,310	30·5	23·0	42·9
3	26,290	49,020†	12·0	—	46·6
4	27,450	46,180	40·5	28·9	40·3
5	24,750	46,400	38·2	27·2	50·2
6	24,720	40,040	46·0	29·6	60·0

* Punch marks pulled off.
† Broke in grips.

the process that calorized metal cannot be hammered or bent cold, but at a bright red heat it may be bent without injuring its resistance to oxidation. Calorized metal will successfully withstand temperatures of 1,800° Fahr. without deterioration,



Annealing box, one-half Calorized, the other half Untreated.



Copper rods 1¼-in. diam. showing penetration of Calorization.

whereas untreated metal begins to oxidise noticeably at 1,100° Fahr., and at 1,800° Fahr. its disintegration is extremely rapid. Furnace gases contain proportions of sulphur dioxide and carbon monoxide, which have a very deleterious influence on ordinary metal. Experimental tests have shown that calorized metal is

(*Continued on page* 292.)

DIESEL ENGINE USERS' ASSOCIATION.

June Meeting.

At the last meeting of the Diesel Engine Users' Association (19, Cadogan Gardens, S.W. 3), Mr. H. F. P. Purday, B.Sc., A.C.G.I., A.M.I.Mech.E., read a paper on "Marine Diesel Engines." In referring to the main points of difference in the design of marine Diesel engines as compared with land engines, he pointed out the fact that the hull of the ship, being subject to more or less violent motion, did not form the rigid fonnda-tion which was provided in the case of the land engine. It was therefore necessary to provide for considerable rigidity in the engine frame, or in the seating, in order to avert troubles due to the main bearings getting out of alignment. Crankshafts considerably stronger than those used in land practice must also be provided. To provide means for starting up from any crank position it was also necessary to use engines having a certain minimum number of cylinders, namely, at least six for the four-stroke engines and four for the two-stroke engines.

The Marine Diesel engine had the advantage of unlimited cooling water being available, and with the temperature kept within reasonable limits there was practically no deposit. This was a great advantage in reducing the risk of piston seizure, cracked covers and cracked pistons, &c. All marine Diesel engines were also fitted with crossheads and guides which practically eliminated the trouble of piston seiznre.

In dealing with fnel-injection systems the author stated that, so far, the best fuel consumption with the solid-injection system seemed to be associated with high maximum pressnres, which were penalised by the registration societies. When the maximum pressure was limited to 500 lbs. per square inch, the fuel consumption was usually slightly higher than with the air-blast system.

The author discussed the thermal difficulties of large Diesel engines, aud pointed out that the trend of modern design seemed to be to eliminate extensive temperature stresses by dividing the castings into smaller pieces having considerable freedom from expansion. He favoured the practice of providing concave crowns to pistons as the farther the centre of the crown was away from the fuel valve the less heat it would presumably receive. The view was expressed that the Diesel engine must be seriously considered in the near future for propelling large engines requiring something like 16,000 s.h.p per shaft.

Annealing box cover, showing small Calorized rectangular portion.

OIL AND THE DONKEY BOILER.

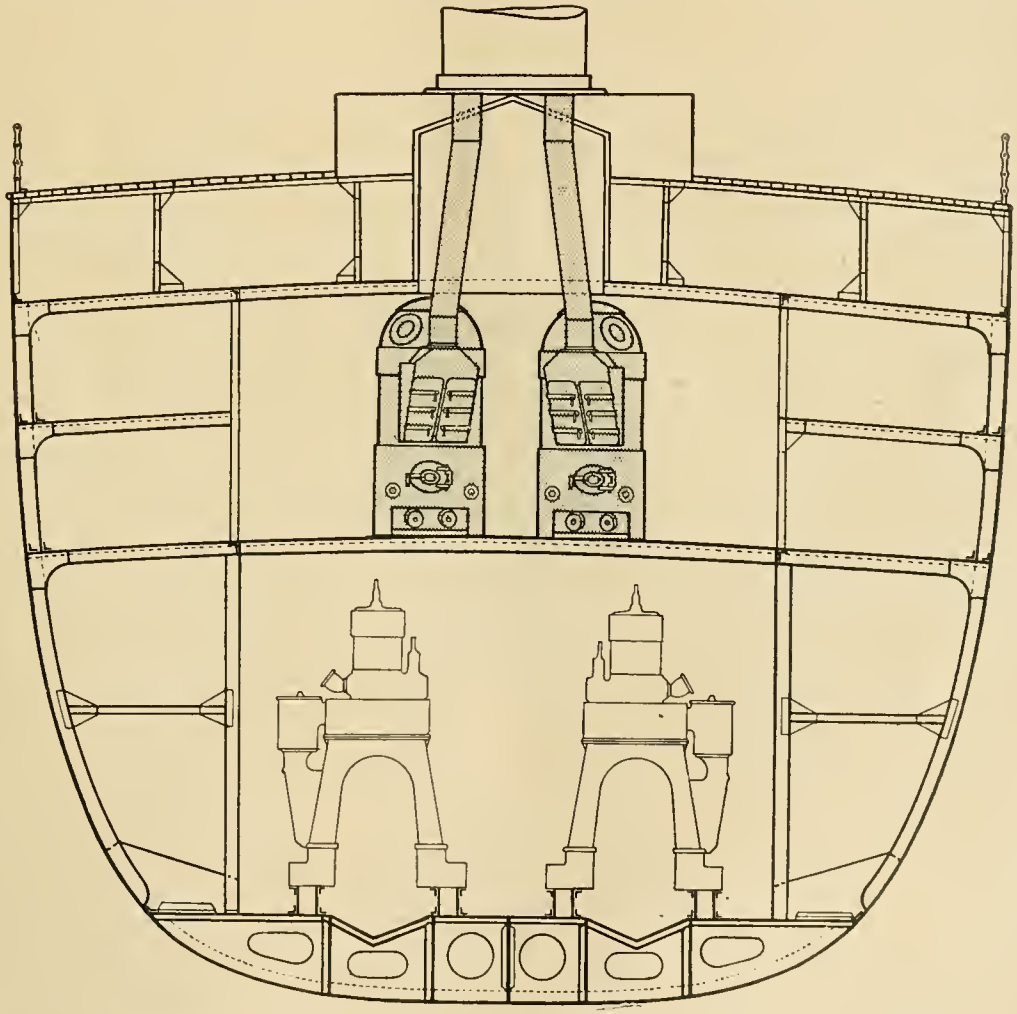
Function of the Donkey Boiler—One or Two Boilers for Motorships—Steam Consumption of Auxiliaries—Low Heat Value of Diesel Engine Exhaust Gases.

The coming of oil as fuel, whether burned in a boiler furnace or an engine cylinder, has directed attention to that most important, but hitherto largely neglected item of ship equipment, the " donkey " boiler.

While some progressive superintendents were in the habit of specifying that their vessels should have some kind of multitubular boiler, others, and unfortunately a large part of the total, still stuck to the old wasteful " crosstube " type, which, standing dirty, neglected and inefficient in its dark stokehold recess, was anathematised by stevedore and engineer alike. But even the most old-fashioned engineer could not contentedly contemplate burning an expensive fuel like oil in a boiler which merely wasted it, not only on account of running costs but because it meant increased bunker space as well, itself a costly item.

The new problem divided itself roughly into two. First, the adaptation of the oil-firing gear to the boiler; secondly, the size of the boiler itself under the new conditions. The precise type of boiler does not present so much difficulty, the choice lying between the ordinary " Scotch " pattern or the vertical multitubular pattern. It is sometimes objected that, in a big ship, only a horizontal boiler can be fitted as the vertical is not large enough for the duty required, but this objection will not stand examination. The modern multitubular vertical boiler is made sufficiently big to evaporate about 7,000 lb. of water per hour from cold feed, and two of them will go into less space in plan than a horizontal boiler of corresponding power.

At this point it would be as well to state that the words " donkey boiler " are used to denote the boiler which, in a ship, is usually employed in port to run the winches, dynamo and other auxiliaries, but has nothing to do with propelling the vessel. It is now applied also, though incorrectly, to the boilers generally carried on Diesel engined ships because they perform approximately the same functions as on a steamer, though of course, there are no main boilers. This " donkey " or auxiliary boiler on such vessels has an extraordinary and heavy range of duties, and its size should be properly proportioned to them. There used to be a rough sort of rule in steam vessels of the ordinary cargo type, that the auxiliaries required about 16 per cent. of the total evaporation of all the boilers in the ship, so that the auxiliary steam bore a distinct relation to the horse-power. In motor vessels this rule of thumb is, of course, quite useless, and the only way to arrive



Arrangement of Donkey Boilers on Main Deck of Twin-Screw Motorship.

at anything like a correct result is to tabulate the various duties for which the boiler is to supply steam and get as near as possible to the steam requirements of each item. As a rule these steam requirements can be obtained from the makers of the particular gear. As to what auxiliaries really are to be dealt with on a motor vessel, the ship *Dominion Miller*, illustrated and described in our March issue, will form a good example. There are on the deck of this vessel, 12 7-in. double-cylinder winches, which may conceivably all be working together. What these will need in the way of steam may be seen from the above table, which is taken from a paper by Mr. C. F. A. Fyfe, read before the Institution of Engineers and Shipbuilders in Scotland.

Lb. of Water Per Hour for One Winch.

Diameter of Winch Cylinders (in inches)	9 × 12	8 × 12	7 × 12	7 × 11	7 × 10	6 × 12	6 × 11	6 × 10
Driving hard (recklessly)	2790	2220	1700	1550	1420	1250	1150	1040
Proper handling	1930	1530	1170	1075	980	870	790	722

The above figures are for Atlantic working. The consumption is distinctly less in the Tropics.

In addition, while the winches are going, probably the electric lighting set will be running, as well as the boiler feed and oil fuel pumps. It is further possible that the ballast pump, refrigerator and evaporator may be going occasionally and some steam used on the various heating systems. In a cargo ship this will not be a large amount as there will only be the fuel for the boiler and engines to keep warm, even if this. The steam requirements will really vary with the position of the tanks in the ship. The double bottom, for instance, is a very cold place for oil, which is apt to get rather viscous there. Adequate heating pipes are in such cases necessary. A fairly safe rule is to take one square foot of heating surface per ton of oil in the tanks and assume that this heating surface will require half a pound of high-pressure steam per hour. Cabin heating by means of radiators does not take much and probably a third of a pound of low-pressure steam per square foot of radiating surface per hour will be ample. On the other hand, in an oil tanker the steam for heating the oil is very considerable, and the oil must be kept fluid if the pumps are to discharge the cargo without trouble. Of course, in this case there will be no winches requiring steam, and in the majority of tankers it is not the practice for the boilers to steam the discharging pump, steam being usually brought by means of a flexible pipe from a boiler-house ashore, the object being to lessen fire risks. At sea the steam requirements will be considerably different from those in port. No tank heating at all may be wanted, though cabins and galley will both require steam, and no winches would be going. The steering gear will be running, as also the various pumps in connection with the main engine, such as the water jacket and guide cooling pumps. In addition there would be the electric lighting set and ballast pumps. The total of these, however, is small compared to the demand for steam when all the winches are going.

It is obvious, therefore, that a single boiler would be running "light" at sea, while it might be running with an overload, and, consequently, inefficiently in port.

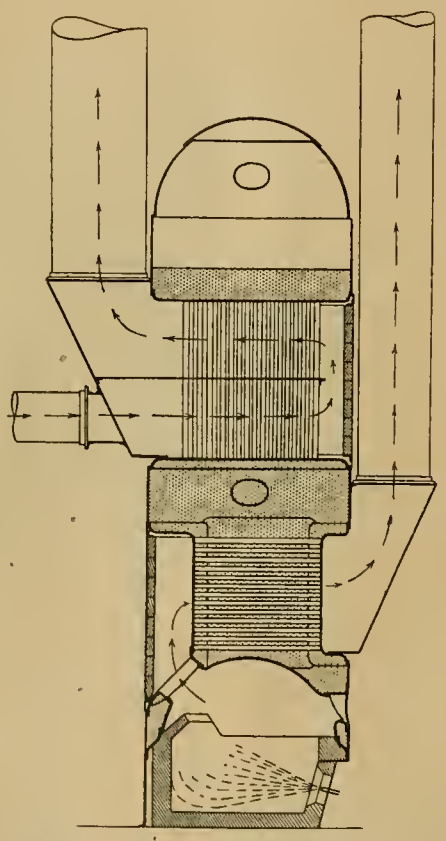
The logical deduction from this is the fitting of two boilers, one to be kept going at sea, while both are under steam when loading or discharging cargo. This arrangement has, as a matter of fact, become almost a standard one, particularly in the large modern Italian motor vessels, where two multitubular vertical boilers are placed on the main deck as shown on page 285. The advantages claimed over a single horizontal boiler by this scheme are :—

(*a*) The boilers can always be kept clean and efficient, as one can be opened out at sea while the other is steaming.

(*b*) In case of a mishap, *e.g.*, water let down, one boiler would be available at least, and work would not be entirely stopped.

(*c*) Steam can be raised much more quickly.

(*d*) In the event of the ship being flooded the boilers are more likely to be kept running, and therefore, available for operating the wireless than when below.



Donkey Boiler designed to utilise heat from Main Engine Exhaust Gases.

These advantages lie really in the use of two boilers instead of one, but there are other distinct advantages arising from the type of boiler adopted. The first of these is the speed with which the steam can be raised. In the vertical boiler there is no mass of "dead" water below the firebars as there is in the "Scotch" boiler, so that steam can be raised more quickly and the boiler does not suffer from unequal expansion stresses as a horizontal unit does. The second is the absence of all stayed surfaces, which permits of complete accessibility for cleaning, and a third lies in the ease with which oil-firing gear can be adapted to the boiler. As remarked above, this duplex boiler arrangement is becoming almost a standard arrangement, for even where they are not fitted on deck the vertical multitubular boiler can be, on account of its small floor space and general shape, readily accommodated in corners of the engine room. An illustration of this occurs in the, *Dominion Miller* already referred to. The principle is, however, being carried still further, as it is recognised that even one of two equal sized boilers may be bigger than what is required for use at sea. The latest design accordingly embodies an arraugement with one small and one large vertical boiler—the small one for use at sea, the large one for use in port. Steam can be raised very rapidly in the large boiler as the necessary steam will be available on the oil-firing gear from the small boiler, which will be at work when the ship reaches port. There will be then no trouble with delay in lighting up.

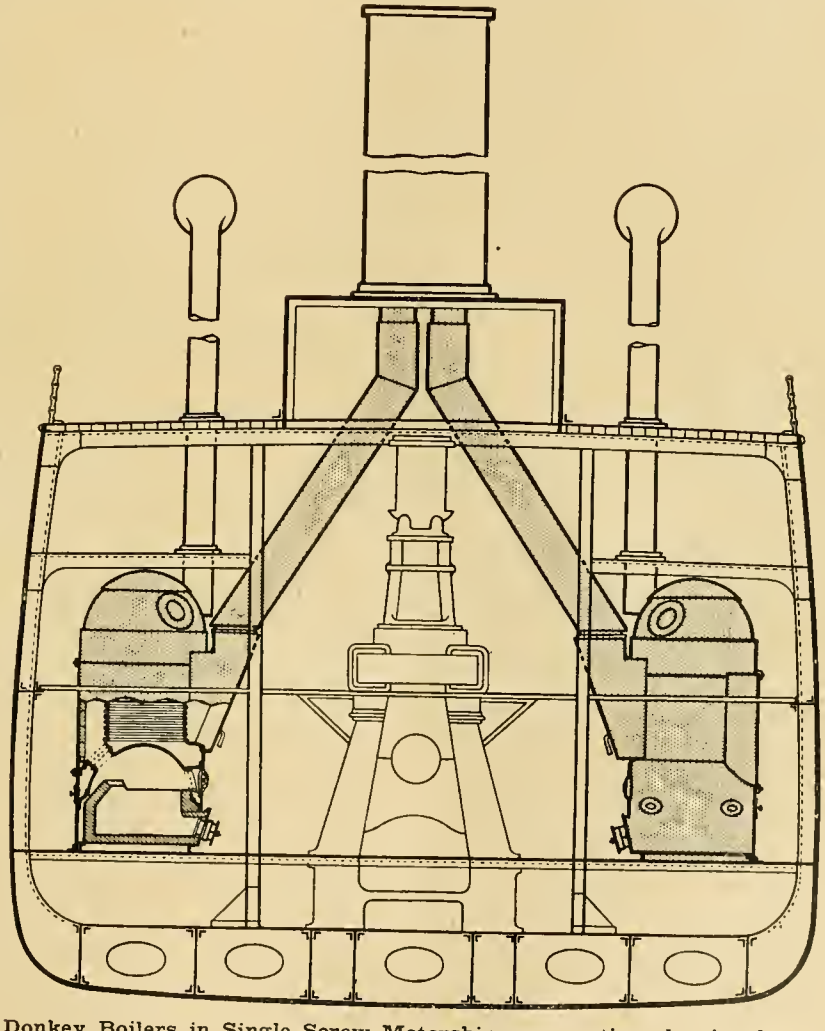
Many people cannot see an illustration of a boiler in a motor engined ship without jumping to the conclusion that it ought to be fired with the exhaust gases from the engine. This is a most alluring problem and needs to be very carefully considered. In the first place it will be obvious that by fitting a boiler (through which all the gases pass) on the exhaust pipe there will be a serious liability to increase the back-pressure. Again, as the temperature of the gases is low (or ought to be in an efficient engine) the steam generated by the use of these gases does not as a rule pay for the interest on the capital

sunk in the special exhaust-gas boiler. The formula here suggested will enable anyone to see for themselves how much steam they are likely to get :—

$$W = \frac{P \times O \times G \times S\,(T - t)}{H}$$

W = Theoretical weight of steam per hour.
P = Indicated horse-power of engines.
O = Consumption of oil per indicated horse-power per hour.
G = Weight of exhaust gases per lb. of oil.
S = Specific heat of exhaust gases.
T = Temperature of exhaust gases entering boiler. Deg. Fahr.
t = Temperature of exhaust gases leaving boiler. Deg. Fahr.
H = Total heat of steam at pressure required.

As an illustration it will be interesting to take the relative figures from a recent magazine of a motor vessel of 11,000 tons. This is a twin four-cycle job, which developed an average of 4,619 indicated horse-power total on a three days' trial. The oil consumption is given as 0·297 lb. per indicated horse-power per hour, the temperature of the exhaust as 346° C. It is this temperature (T in formula) from which we work, and it goes without saying that after the gases have passed through the boiler they should not be lower than the temperature of the steam at the pressure at which it is being evaporated (t in formula). If this pressure is 100 lb. then the limiting temperature is 378° Fahr., though this is quite a theoretical figure as there would be no draught worth speaking of in the funnel if it really fell so low, and there is no allowance for transmission losses. We think a reasonable view is to take this final or funnel temperature at 450° Fahr., and working out the figures from the data given, with G at 30 and S at 0·24 we get a theoretical amount of 1,708 lb. of steam available per hour. Taking a practical common-sense point of view it will not be possible to get more than 80 per cent. of this steam, due to the various losses in the exhaust pipes, &c., so that, at 80 per cent., we see the total steam indicated as being practically available in very large engines is only about 1,270 lb., *i.e.*, hardly worth considering. To this must be added possible trouble from back-pressure and also risk of corrosion of the boiler tube plates due to leakage as the gases deposit various acids. Notwithstanding these objections some engineers are opposed to giving up this idea, and to meet them the design of boiler illustrated on opposite page has been evolved. It will be seen that it consists of a vertical multitubular boiler with the shell extended to take a number of tubes of small diameter over which the exhaust gases play. There is much less risk of increasing the back-pressure by passing the gases over tubes instead of through them, and there is no risk of back-firing or any explosion of the kind from ignition of the gases by the oil-firing of the lower part of the boiler which is necessary to make up the required workable amount of steam. The vertical tubes "draw" into the steam space of the boiler, and larger tubes are fitted at the sides and properly baffled to form a passage for descending currents. The casing is provided with doors for sweeping the tubes, and, of course, an inlet and outlet for the waste gases, the former of which is of such a height that a straight flow without bends is obtained, the bottom of the boiler being on the engine foundation framing, and its oil-firing gear accessible from the engine room platform.



Donkey Boilers in Single-Screw Motorship, one section showing large furnace for oil-firing.

So far the first half of the problem alluded to in the beginning of this article has not been discussed, but from the illustrations appended it will be seen how very readily the vertical multitubular boiler adapts itself to a really reliable and desirable furnace arrangement for oil-firing. The ordinary horizontal "donkey" boiler contains as a rule a couple of furnaces of inadequate cubic capacity, and the evaporative results are not very good as the necessary quantity of oil can really not be burned. A large and ample furnace is an absolute necessity for oil-firing, and how easily this is effected in the vertical multitubular boiler is shown by the illustration herewith. Again, with the ordinary horizontal boiler, one is tied to the position of the oil-firing gear, that is, it must be in the front of the boiler. On the other hand, in a vertical boiler the jets can be arranged to discharge into the furnace at any point on the circumference of the boiler, and in cases where space is very much restricted, this is a very valuable asset. But whatever type of boiler is adopted, and whatever type of oil-firing gear fitted, it is of the utmost importance to see that perfect co-ordination is obtained between the boilermaker and the manufacturer of the oil-firing gear. The shipbuilder is generally inclined to order these two items separately with very little regard to mutual suitability. They should be considered as one unit, and the wisest and safest plan is to place the order for the gear along with the boiler, making the boilermaker responsible for suitable design and performance of the whole plant.

WM. BEARDMORE & CO.'S DALMUIR WORKS.

Early History of Dalmuir Establishment—Developments in relation to Modern Practice—Shipyard Progress—Manufacture of the Beardmore-Tosi Diesel Engine.

As the successors of the world-famous firm Robert Napier & Sons, the pioneers in the development of the compound and triple-expansion engines and the high-pressure marine boiler, Wm. Beardmore & Co. have worthily upheld the high standards set. Modern developments in marine propulsion have introduced the steam turbine reduction-gears and internal combustion engines, and the Dalmuir firm have, by a far-sighted progressive policy, contrived to reach a position in the forefront of modern practice. Such a position has not been reached and maintained without effort. The entire engineering establishment at Dalmuir has in recent years been replanned on scientific lines and the most up to date equipment has been introduced.

A total area of 15 acres is covered by the fine machinery shops at Dalmuir, and the engineering and boiler making department, which is situate to the west of the fitting-out basin, occupies an area of 5½ acres. Among the more important sections of these works is the main engine shop, which has been particularly well conceived. This shop has an overall length of 720 ft. and is arranged in five bays, two of these bays having a width of 60 ft. and three having a width of 75 ft. On page 263 we produce a photograph from which some idea of the lay-out of these shops may be gathered. In the foreground may be seen a section of the double-reduction geared turbine equipment of the Cunard liner *Tyrrhenia*, which has just been fitted out at the builders' Dalmuir basin. Another view of the same equipment is shown on page 263. Each bay of the engine and boiler shops is traversed by standard gauge railway lines and is served by overhead and shop-side cranes. A line system of production is employed throughout, whereby all material, such as forgings, castings, boiler plates, &c., enters at the centre of the shops and travels through the various processes of completion to the extreme end of the works. In the process of preparation the engine materials travel southwards towards the erecting section, while the boiler materials move northwards to the place of erecting. North and south lines of railway take the completed engines and boilers from the shops to the fitting-out basin where they are placed on board by means of a large cantilever crane. The capacity of the shop and fitting-out crane equipment varies from 5 tons to 140 tons. On page 264 is shown, in the process of construction, a section of the propelling machinery for the twin-screw Italian liner *Conte Rosso*, recently completed to the order of the Lloyd Sabaudo, of Genoa.

The great increase in the application of double-reduction gears has necessitated the laying down of special plant for the cutting of these heavy gears, and the enterprise of the firm in this connection is demonstrated by the fact that a large number of high-power geared sets have been cut for vessels of their own construction, in addition to several large sets supplied for vessels built elsewhere. A detailed description of the shop equipment is beyond the scope of this article, but special reference should be made to a large lathe which is designed for use on propeller shafts. This lathe is capable of accommodating shafts up to 88 ft. in length and has a bed of 100 ft. in length. This lathe is believed to be among the largest of its kind to be found in the Clyde district.

Concurrently with the improvements effected in the machinery shops, similar schemes have been proceeded with in reference to the shipyard section at Dalmuir. The east yard, recently laid out, represents one of the most modern and finely equipped yards on the Clyde. There are four building berths, one of which is 550 ft. in length, two 500 ft., and one 400 ft. This yard, which covers an area of fully 12 acres, is entirely self-contained, having its own platers' sheds, equipped with cranes and other appliances of the most modern type. While the firm will continue to build the larger classes of ship at their main establishment, the new yard will be devoted mainly to the construction of vessels of the intermediate class.

In addition to their other marine activities the firm are engaged on the construction of Diesel engines of the Beardmore-Tosi type. Two sets of four-cycle engines of 1,250 b.h.p. were ordered by MacAndrews, of London, for two vessels of 3,300 tons displacement for their fruit-carrying trade from Spain and the Mediterranean. Both vessels were built by Beardmore's and the first of these, the *Pinzon*, has recently given highly satisfactory performance on service. The second set of engines for the *Pizzaro* is now under construction at Dalmuir.

THE TRANSVERSE METACENTRIC HEIGHT OF SHIPS.—IV.—(*Concluded from page* 260).

normal sheer. We have, therefore, as the normal freeboard is 5 ft., and the effective bridge 'tween deck height $= \frac{77}{305} \times 7$ $= 1{\cdot}76$ ft., the total effective freeboard equals $5 + 1{\cdot}7 + 4{\cdot}85 + 1{\cdot}76 = 13{\cdot}31$ ft.

∴ the value of $\overline{GM}$ at 90 deg. equals

$$\frac{13{\cdot}31}{1 + \frac{\bar{r}}{\alpha}} \text{ B}_{\text{o}}\text{G}$$

$$= \frac{13{\cdot}31}{1 + \frac{{\cdot}80}{{\cdot}88}} - (16{\cdot}0 - 8{\cdot}7) = 7 - 7{\cdot}3 = -{\cdot}3 \text{ ft.}$$

The first deck-edge spot occurs at an angle $\tan^{-1} \frac{2 \times 5}{44}$ $= 13°$ approximately, and is above the M.M. line at distance $\frac{5^2}{6 \times 16{\cdot}6} = {\cdot}25$ ft. The second deck-edge spot occurs at an angle $\tan^{-1} \frac{2 \times 13{\cdot}31}{44} = 30°{\cdot}25$ and is above the M.M. line at distance $\frac{13{\cdot}31^2}{6 \times 16{\cdot}6} = 1{\cdot}78$ ft. These values are inserted in Fig. 11, and the resulting curve confirms the opinion that the vessel chosen was well suited for the timber trade. Its initial stability was sufficient, although not excessive, and its range of stability, *i.e.*, 86 deg. is quite ample.

Throughout this article the aim of the writer has been to review the technical work associated with the provision of adequate stability, and to outline methods whereby the stability of a proposed design can be rapidly examined without the expenditure of the time which would be necessary for a detailed calculation.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Riveting Stresses.

The stresses produced in plates due to the presence of rivets are very complicated and difficult to determine. These stresses are due first to the considerable pressure necessary to close the rivet, and second to the high temperature of the rivet. Of these two causes the latter is the more important, and in order to examine the full importance of these heat stresses Prof. Baumann has carried out an important series of researches. His main object was to find whether the steam pressure of boilers can be safely raised with the existing types of riveted joints. The apparatus used is described, and the following are Prof. Baumann's conclusions :—

1. High riveting pressures stress the plate material above the elastic limit.

2. The temperature of the plate may exceed 500° C. during riveting and produce a stress in the plate considerably higher than the elastic limit.

3. The maximum stress occurs at the faying surface of a joint near to the rivet-hole and also between the hole and the edge of the joint.

4. With rivets very close to the edge of the plate the stress and heating increases very considerably. It is preferable to have a good clearance between the rivet and the edge of the plate, even at the consequent expense of the efficiency of caulking.

5. High riveting pressure is to be avoided. Pressures of 40 to 50 tons per sq. in. produce rivet heads which can be safely caulked.—*Zeitschrift d.V.d. I.* May 20, 1922, p. 501 ; 1 p., 8 ff.

Cable Vessels.

As a new cable vessel is to be constructed in Holland for the Dutch East Indies this article has been prepared to describe the usual construction, outfit and functions of this class of vessel. As a typical ship the ss. *Telegraaf* (ex *Von Podbielski*) built by Dunlop, of Glasgow, in 1900, is taken, and her internal arrangement described in detail, each main item receiving attention. Next, the general questions of design are outlined. Cable vessels must be capable of being carefully manœuvred and are thus of necessity twin-screw vessels. Because of the long nature of their voyages a considerable reserve of fuel stores must be provided. The ballasting of these vessels has to receive considerable attention to ensure even trim when raising or paying out cable. The author next outlines the various types of cable which have been used, and reviews the work involved in the laying of the more important Dutch cables.—*B. Holthuis, Het Schip*, June 2, 1922, p. 150 ; 5 pp., 10 ff.

Patent Enamel for Ships' Propellers.

It is well known that the reduced resistance and consequent greater efficiency of bronze propellers, due to the smoothness of their surface, has led to their general adoption in vessels of high and moderately high speed. This adoption has taken place in spite of the high initial and upkeep costs of the bronze propeller. Whilst adequate strength is required in a propeller it must not be so strong as to transmit the force of a blow to the engine itself ; and probably for this reason and their cheapness, cast-iron propellers have persisted in ordinary merchant ships. Many attempts have been made to produce a paint or enamel which will present a permanent smooth surface on a cast-iron propeller, but because of the brittle nature of the enamel and the vibration and shock of the propeller, very little success has been achieved. However, the Helix-Maschinenbau Co. have recently patented an enamel coating for propellers which has been shown to be sufficiently strong to withstand the vibration, and being more ductile than the cast iron or cast steel only breaks after the metal itself has broken. The adoption of this enamel presents, therefore, considerable opportunity for economy in the upkeep and running of merchant vessels. The surface of the enamel is also anti-fouling as well as, of course, anti-corrosive. The cost of an enamelled cast-iron propeller is half that of a bronze propeller for the same efficiency. The enamel is white in order that when ropes happen to become entangled with the propeller their release may be facilitated. The enamel is being increasingly adopted, especially in Holland.—*M. Becker, Schiffbau*, May 31, 1922, p. 1040 ; 1½ pp.

Standardisation in Shipbuilding.

The general functions of standardisation are first outlined and then the author proceeds to consider the particular problem of ships' fittings. The question of side-lights is taken as a particular case, and the advantages of standardisation to the ship owner, shipbuilder and manufacturer are clearly demonstrated. Next, the limits of standardisation are considered and a study is made of which dimensions should be made standard in a given product, in order that, in spite of minor differences of scantling, the principle of interchangeability may be adhered to. In this connection the question of permissible tolerance receives attention. The necessity for careful initial consideration of the standardising of a particular product is emphasised, and cases are mentioned which although apparently simple yet involve a considerable amount of technical work. The author next deals with the progress of standardisation in Germany. By the end of 1922 the German commission hopes to have published some 450 standard detail sheets. The advantages claimed by the German commission for standardisation are numerous. Elimination of much time-wasting discussion with marine superintendents is quoted as the first advantage ! Invariably standardisation results in a saving of time, money and material. In the case of one 9,500 ton deadweight ship a saving of 1 ton was effected by the adoption of standard bollards. Finally, the work and organisation of the Dutch commission is dealt with. The commission is divided into two main groups similar to the English, the Amsterdam group, and the Rotterdam group. The individual work of these groups is tabulated ; and it is interesting to note that their recommendations are being published in the technical press as soon as they have been definitely adopted.—*I. R. Mulder, Het Schip*, April 21, 1922, p. 111 ; 6½ pp., 7 ff.

The Deutz Hot Bulb Engine.

The Deutz Company have recently brought out a successful two-stroke hot bulb engine. The engine works without water cooling, the fuel injection and the hot bulb being so designed to avoid overheating at full power, and yet be sufficiently hot at low powers to ensure continuous firing. The cylinder head is fitted with two fuel injection valves, which are separately regulated from the fuel pump. The valves are at different heights, the lower injecting into the compression space and the upper into the hot bulb. At full load the greater part of the fuel is injected through the lower valve and at light loads through the upper. The engine works well and has an efficient range of revolutions from 400 r.p.m. at full load to 200 r.p.m. at light load. The full consumption varies with the size of the machine between ·59 and ·661 lb. per b.h.p. The cycle of operations is similar to the usual two stroke. The engine can be used for the main drive of screw-propelled small craft, the driving of dynamos and for the driving of auxiliary compressors for Diesel engines.—*Der Kleinschiffbau*, May 27, 1922, p. 147 ; 1 p., 4 ff.

Design of Turbine Blades and Screw Propellers.

This article forms a very comprehensive treatment of the subject. First the fundamental hydrodynamic theory is outlined, and from the basis of the well-known Bernoulli equation, the general problem of a rotating blade is considered and equations deduced for the useful work developed by the blade. The treatment is similar to that used in aerodynamical investigations, and use is made of the lift and resistance coefficients of usual types of blade, the values of the coefficients being obtained from the results of aerodynamical research. The theory once established is then applied to the design of a particular case, the example being worked out in full detail. Next, the analogous fundamental theory of the screw propeller is outlined ; the nature of the treatment being quite different from that usually met with in naval architectural works. As before, equations for the useful work and efficiency of the propeller are set up on the same general basis, making full allowance for all losses such as friction, &c. Finally the method is applied to the design of a particular propeller, and although the application appears complicated, the comprehensive nature and validity of the fundamental assumptions assures a reasonably accurate result. The article is of a mathematical nature, but the mathematics are clearly illustrated by a number of lucid diagrams.—*Dr. Bauersfeld, Z.d.V.d.I.* May 13, 27, pp. 461, 514 ; 8 pp., 13 ff.

The Schmidt Smoke Tube Superheater.

A new type of superheater, known as the Schmidt intermediate chamber superheater, has recently been successfully adopted in several sea-going and river vessels. The new type differs from the old in so far as the superheater tubes are not individually connected to the collector, but several tubes are united and led and welded to triangular intermediate chambers. Only one collector or header is necessary, it being divided into three chambers, the two outer being connected to each other at the top of the collector and forming the wet steam chambers, whilst the hot steam is led to the centre chamber. The intermediate chambers are so constructed that the wet steam coming from the collector passes through them and along the superheating tubes and then back again through the intermediate chambers and thence to the centre chamber of the collector and to the main machinery. The new construction reduces the number of requisite steamtight connections and is more easily dismantled than the older types. The superheater shown in the article has been fitted to several 150 h.p. tugs with such success that 15 more tugs are to be so equipped. The boilers of these craft are of the return-flame tube type, having a heating surface of 600 sq. ft., and a working pressure of 162 lb./sq. in. The superheater has a heating surface of 227 sq. ft. It is claimed that by the adoption of this type of superheater the fuel consumption may be reduced to the extent of 15 to 18 per cent.—*Der Kleinschiffbau*, May 27, 1922, p. 143; 1½ pp., 2 ff.

Shipbuilding Estimates.

This article deals principally with estimating for small ships. The author regrets that this subject has received so little attention in the technical press and deplores the secrecy of the German shipbuilders. He emphasises the necessity for some definite system in estimating, but takes care to point out the futility of multiplicity of schedules, forms, &c., in replacing sound management. The author considers that replies to enquiries are treated very cursorily by shipbuilders, and maintains that a more detailed estimate will in all cases give the shipowner or broker greater confidence in the methods and reliability of the builder. To this end the most convenient manner of producing such an estimate for a small shipyard is dealt with. A careful examination of previous work, and especially of the material issued from the store, together with the time taken to complete each constituent part of the ship, will enable a reliable means of estimating to be set up. Having harnessed the data, typical forms are drawn up which enable the cost, weight and completion period of the main structural items to be estimated with a certain degree of reliability. The further allowances for wages, depreciation of plant and establishment charges are included on these forms. The estimate thus obtained in detail is then abstracted for submission to the particular client. The form used comprises the general particulars of the vessel and the weight and time of completion of the main structural items, and finally, the total cost of the vessel. In the author's opinion the adoption of such a procedure will always create a favourable impression in the client, and even if the desired contract is not secured the firm will always gain something in prestige by its businesslike methods.—*Dr. D. Brasch, Der Kleinschiffbau*, April 22, 1922, p. 115; 3½ pp., 3 ff.

Navigation of the Congo.

This article passes in review the geographical conditions of the Congo and considers the various types of vessel which have been and are being used on the rivers of Equatorial Africa. The Congo basin is very carefully considered and the influence of the local conditions on the type of vessel is discussed. The depth of the Congo varies greatly throughout the year, and the number of rapids and the shifting nature of the sand forming the river bed necessitate a distinct type of vessel. Such vessels must of course have a shallow draught and must have a strong bottom structure in order to resist the dynamic and erosive effects of grounding on the sand. They must be well subdivided by bulkheads because they are frequently bilged by sharp rocks when passing through the rapids. The trim of these craft should be easily controllable, and should preferably be a trim by the head rather than by the stern because, in grounding, the vessel is much more simply released when her nose is in the sand than when the greater portion of stern takes the ground. These vessels can be propelled by paddle-wheel or by screw propeller. The usual type of paddle is of course the stern wheel with fixed floats. This type is very simple to repair and is very easily controlled. The stern wheel is very useful in case of grounding, the astern power being equal to the ahead. Disadvantages of the stern wheel are its low propulsive efficiency and the vibration it sets up in the main structure. This latter is eliminated in passenger vessels by fitting feathered floats. Screw propellers fitted in the customary recess are much more efficient, and therefore engines of less horsepower and weight than the paddle engine can be fitted. On the other hand, the screw is much more difficult to repair. On rivers in which much vegetation and weeds are found, air propellers only can be used, and these have been fitted to several small craft. In the absence of coal, wood and mazout are the only fuels extensively used at present, but petrol is coming into more common use. One of the greatest difficulties is labour, due, of course, to the severe climatic conditions. The annual trade is approximately 60,000 tons exports and 30,000 tons imports. The general size of vessels is now approximately 500 tons G.R.T., although vessels of 1,000 tons G.R.T are at present contemplated. The remainder of the article describes several of the vessels now in use on the Congo. The majority of these have been built by Cockerill & Co. and Yarrow.—*Bull. Tech. du Bureau Veritas*, May, 1922, p. 109; 6 pp., 10 ff.

Pneumatic Apparatus for Boiler Cleaning.

Considerations of fuel economy necessitate the periodic scaling of boiler plating and tubes. Very often chemical means are adopted to carry out this work, but the consequent high cost has tended to favour the use of more mechanical methods. However these latter methods, such as hand, pneumatic or hydraulic chipping are not always satisfactory and damage to tubes may easily be incurred. A new pneumatic boiler scaler has recently been adopted which is equally efficient for tube and plate cleaning. In this apparatus, which is specially designed to pass into tubes, a low air pressure of six atmospheres is used. The chipper itself is directly connected to the pneumatic piston at the head of the apparatus. The apparatus is of course tubular, and is about 2 ft. 6 in. in length. Inflow of air is regulated by the usual spring sleeve valve. The apparatus is easily dismantled and the chippers can be simply renewed or sharpened. As a low air pressure is sufficient, only a single-stage compressor is required. Unskilled labour is sufficient for the manipulation of the apparatus, and it is claimed that with its use three to four times the amount of work capable with the older methods may be accomplished. The apparatus can also be used for the cleaning of foundry castings, the chipping and scraping off of rust from a ship's plating, and the cleaning of all kinds of iron and steel construction prior to painting. The tool is described in detail and diagrams of its construction and use are given.—*Schiffbau*, May 24, 1922, p. 1016; 2½ pp., 5 ff.

The Manœuvring of Diesel Engines by Compressed Air Turbine.

In a long and comprehensive series of articles the author, Dr. Praetorius, considers the whole question of the manœuvrability of Diesel engines. Manœuvring effected by the introduction of compressed air into the working cylinder is considered by the author to be unsound and opposed to considerations of simplicity and safety. Manœuvring is most efficiently carried out by means of an auxiliary motor which may be either the usual reciprocating type driven by compressed air or gas, or an electro-motor, or finally, the author's own proposal—a compressed air or gas turbine. The considerations leading to the adoption of this type of auxiliary are outlined at length. The turbine is directly coupled to the main engine, and in the case of a four-stroke Diesel the turbine takes the place of the usual flywheel and thus no extra weight is involved in its introduction. Next the construction and design of the turbine is described. Experiments were then carried out on various existing engines, these being a 60 b.h.p. four-stroke Diesel, a 100 b.h.p. six-cylinder Diesel built by Benz, of Mannheim, and finally, a 70 b.h.p. three-cylinder Diesel, also by Benz, which was tested both on the test bed and aboard ship. Full details of these experiments, which are claimed to be successful, are given in considerable detail. These experiments are then carefully analysed and examined in the light of the practicability of a specially designed Diesel engine to be manœuvred by a compressed air turbine. This engine is a 50 b.h.p. four-stroke, and full detail plans of its construction are given. The advantages claimed for the system are briefly as follows:—

1. Simplicity of manœuvring mechanism and control.
2. Greater safety and reduced working stresses.
3. Cheaper crankshaft and better balancing.
4. Fewer working cylinders.
5. Lower repair costs.

The article is very complete and contains a considerable amount of information.—*Dr. P. Praetorius, Schiffbau*, April 12, 19, 26, May 10, 24, 31, 1922; pp. 851, 879, 911, 959, 1007, 1035; 33 pp., 19 ff.

Twin-Screw Cargo Vessels.

This article gives a very complete description of the German twin-screw cargo vessels *Friesland*, *Sauerland*, *Wendland* and *Münsterland*, built by Bremer Vulkan, of Vegesack. These vessels have the large deadweight capacity of 15,700 tons and have the following principal dimensions: length b.p., 518 ft. 1½ in.; breadth, ex., 64 ft.; depth, mld., 41 ft. 11 in.; draught, 30 ft. 8½ in.; block coefficient, ·80. The sea speed loaded is 13 knots, at which speed an i.h.p. of 5,800 has to be developed. The engines have the following dimensions $\frac{28{\cdot}4 \text{ in.} \times 47 \text{ in.} \times 75{\cdot}5 \text{ in.}}{51{\cdot}2 \text{ in. stroke}}$ the revolutions per minute being 76. The article describes and illustrates all the principal features of the vessels. Amongst the sketches given are the following: midship section, general arrangement, lines plan, cargo capacity plan, deadweight scale, metacentric and stability diagrams, rudder, stern and sternpost constructional plans, and finally the engine general arrangement plan. The model of the vessel was tried in the Hamburg tank, and complete resistance curves for a range of speed of from 10 to 17 knots are supplied. The engine and other auxiliaries are all described. The whole treatment is given in such a form as will prove of considerable assistance to designers engaged on the construction of a similar class of vessel.—*Dr. E. Foerster, Werft Reederei, Hafen*, May 22, 1922, p. 299; 9 pp., 13 ff.

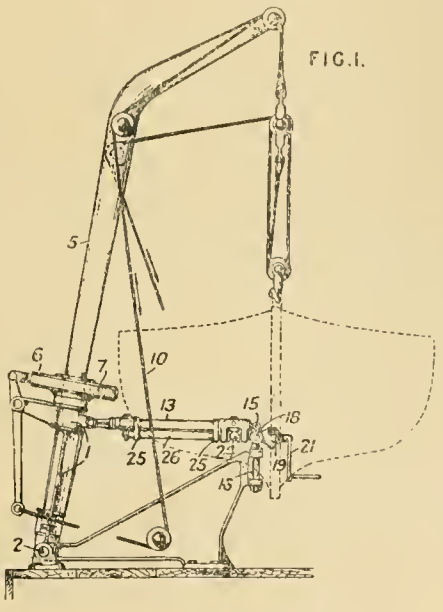
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 177,570. Ships' davits.

Schat, A. P., 3, *Kanaalstraat, The Hague, Holland. November* 25, 1920, *No.* 33296. [*Class* 115.]

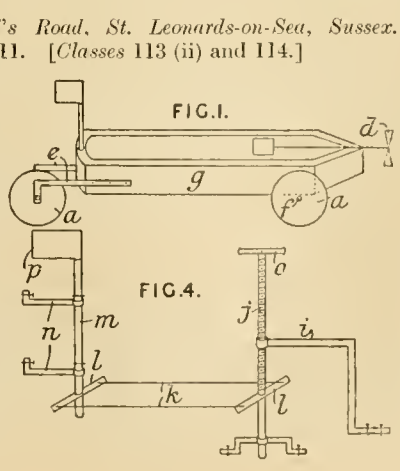
A rotary davit 5 is mounted in a socket 1 which is luffed about the pivot 2 by an extensible member comprising a screw engaging a nut 24 and enclosed by a tubular member 26. The screw is fitted with an operating-handle 21 and is mounted in a swivel bearing 19 pivoted to the forked end 15 of the vertical bolt 16 by means of the horizontal bolts 18. The tubular member 26 is carried by the straps 25 mounted on the tube 13 which has a forked connection with the socket 1, and a telescopic connection through the medium of an internal spindle with the forked end 15 of the bolt 16. In a modification, the tubular member 26 has a direct forked connection with the socket 1. The davits are prevented from turning in their sockets, when luffed to a certain angle due to the weight of the boat, by means of the band brake 7 actuated by the rope 10 and engaging the brake drum 6 on the davit. The rope 10 is associated with mechanism, which may be of the type described in Specification 149,175, for releasing the brake when desired. Specifications 7252/12, 16977/13, 122,595 and 130,470 also are referred to.



No. 177,577. Boats.

Martin, G., 6, *St. Paul's Road, St. Leonards-on-Sea, Sussex. November* 30, 1920, *No.* 33711. [*Classes* 113 (ii) and 114.]

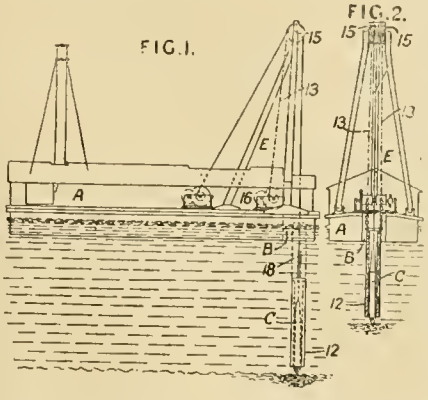
The boat body *g* is supported aft by an air-tight metal ball *a* rotatably mounted on arms *e*; the forward support consists of a pair of similar balls mounted on a crank-shaft *f*. An air rudder *p*, the stock *m* of which is mounted in brackets *n*, is operated by a screw *j*, provided with a handle *o* and mounted in a bracket *i*, through wires *k* and a pair of levers *l*. A tractor propeller *d* is provided.



No. 177,581. Subaqueous rock-breakers.

Lobnitz & Co. Limited and Bedgood, H. O., of Lobnitz & Co. Limited, Renfrew. December 17, 1920, *No.* 35562. [*Class* 68 (i).]

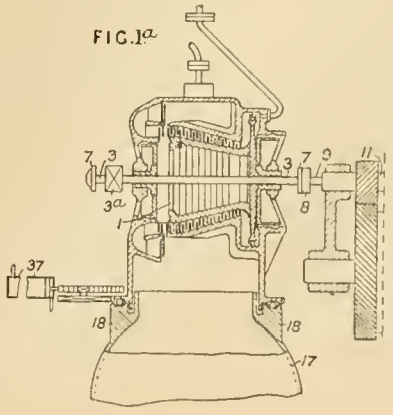
In a subaqueous rock-breaker, the cutter C works in a guide 12 which is suspended by chains or cables 13, in or below a well B in the floating structure A, so that it can vibrate freely without contacting with the floating structure or with any unyielding part in contact therewith. The chains 13 are passed over sheaves 15 on the sheer legs E and are led to a winch 16 by means of which the guide may be raised or lowered to suit the depth at which the cutter is to work. For working at increased depths, additional lengths 18 may be added to the guide. Two or more cutters may be employed on a single floating structure. The guide is lined with wood or other non-abrasive material, and may be of plain or corrugated tubular form or open framework, in lengths united by circumferential flanges, in halves united by longitudinal flanges, or in sections united by both circumferential and longitudinal flanges. The guide may also be telescopically extensible, and may be of such dimensions as to admit a water cushion between itself and the cutter.



No. 177,759. Turbines.

Ljungström, F., Lidingo-Brevik, Sweden. August 31, 1921, *No.* 23135. *Convention date, April* 1. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 80 (ii), 110 (iii), *and* 122 (v).]

The drive of a turbine is reversed without reversing the turbine by turning the turbine end for end in relation to the driven member. Fig. 1[a] shows a turbine 1 rotatably mounted on the neck 18 of a condenser 17 so that either end of the turbine shaft 3 may be clutched through a coupling 7, 8 to a shaft 9 driving a reduction gearing. The shaft 9 passes through a hollow gear shaft 11 and transmits the drive with some resiliency through an axially movable element such as a square coupling. The clutch is operated by a servo-motor. A brake device on one of the gearing shafts preferably controls the servo-motor so that the clutch cannot be operated before the braking is performed; preferably the braking cannot begin before the steam supply is cut off. A brake 3[a] on the turbine shaft



prevents rotation during the turning of the turbine, which may be carried out by rack-and-pinion gearing driven by a servo-motor 37. Fig. III shows a packing between the outlet 19 of the turbine casing and the neck 18 of the condenser comprising packing-strips 40, 43 with a spacing-ring 41 between them and water in the remaining space; a tightening nut 45 is provided. In the case of a turbine of the oppositely running rotor type, one rotor drives through a pair of spur wheels so that the final shaft for that rotor rotates in the same direction as the other shaft of the other rotor of the turbine; the two shafts drive associated reduction gearings. The turbine may be arranged to turn about a horizontal axis. Conical friction couplings or dog clutch couplings may be used. In Fig. VIII is shown a friction clutch comprising a number of segmental annular parts 107 supported by parts 109, 110 on the hollow driving shaft 105 and held in place by an elastic ring 108. A resilient flange of a casing 112 on the driven shaft 106 engages the annular parts 107, on the shaft 106 being moved forward. The annular parts 107 are sprung past the central position and bear on the part 109 with sufficient friction to drive the shaft 106. A rigid flange may limit the movement of the resilient flange. When the coupling is in engagement, as shown in lower half of Fig. VIII, no further axial thrust is required. The turbine aggregate may be applied to locomotive driving, cranks and connecting rods being provided in conjunction with the reduction gearing.

FIG. III.

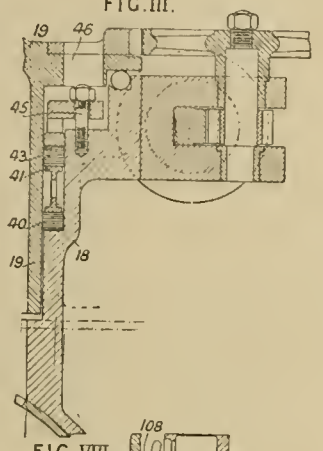
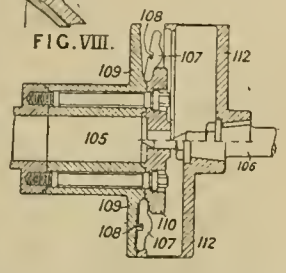


FIG. VIII.



No. 178,489. Ships.

Jackson, P. R., 15, Victoria Street, Westminster.—(*Sperry Gyroscope Company; Manhattan Bridge Plaza, Brooklyn, New York, U.S.A.*) *December* 8, 1920, No. 34679. [*Classes* 113 (i) *and* 113 (ii).]

The hulls of ships stablized gyroscopically are so formed that the normal metacentric height is small but is increased as the ship rolls, with lateral fins fore and aft to minimize pitching and with fuel-tanks so located that as the fuel is consumed the metacentric height decreases at a minimum rate. The hull 31 decreases in breadth from the top to the bottom as shown in Fig. 5, or alternatively as shown in Fig. 6. Fuel-tanks 24 extend across the bottom of the ship and up each side, so that as the oil is pumped out the centre of gravity is raised only to a small extent.

FIG. 5.

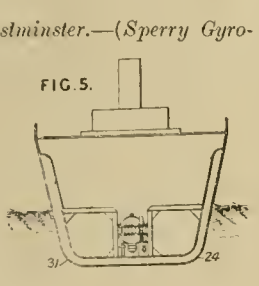
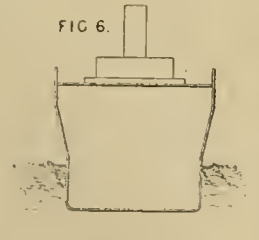


FIG 6.

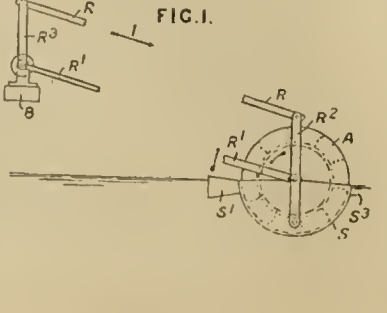


No. 178,658. Turbines, &c.

Hyne, C. J. C. W., Heaton Lodge, Bradford, Yorkshire. March 1, 1921, *No.* 6708. [*Class* 110 (iii).]

Current Motors.—A floating water-wheel A, which operates in a shield S having a coned inlet S^1 provided with a grid and an outlet S^3, is carried by pivoted rods R . . R^3 from a fixed support B. By moving the rod R in the direction I the shield S is tilted so as to put the wheel A out of action.

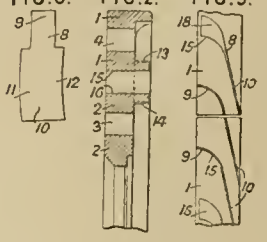
FIG. I.



No. 178,679. Turbines, &c.

Baumann, K., Northwood House, Barnfield, Urmston, Lancashire, and Metropolitan-Vickers Electrical Co. Limited, 4, Central Buildings, Westminster. March 17, 1921, No. 8387. [*Class* 110 (iii).]

FIG. 6. FIG. 2. FIG. 5.



Blades; *nozzles.*—Fins 11, 12, formed on straight portions 10 of blades 8, Fig. 6, fit into saw-cuts in rings or segments 1, 2, Fig. 2, and are welded in position along the surfaces 13, 14; the curved ends 9 of the blades being welded to the rings along their edges 15, 16. The rings 2, 1 have bolt-holes 3, 4 for attaching them to a diaphragm or to an inwardly-projecting rim on the turbine cylinder respectively. Some of the blades may be thickened at their inlet edges 18, Fig. 5, by one of the methods described in Specification 122,323, and the fins may then be continued straight across the blades. The edges of the saw-cuts may be bevelled to receive the welding-metal, thus leaving a smooth surface after welding.

AN IMPORTANT SHIPBUILDING CONTRACT.

In these somewhat lean times in the shipbuilding industry new contracts have become a matter of very rare occurrence. This being so, the announcement that the United Fruit Co., of Boston, U.S.A., has placed an order with Cammell Laird & Co., of Birkenhead, for three insulated, electrically propelled ships for their fruit trade will be generally welcomed. It is longer than we should care to say since such an order has been placed in this country, and the Birkenhead establishment are to be congratulated on the enterprise manifested in securing it. Two features of particular satisfaction to the industry of this country are to be observed. First that the order comes from America, where the principles and the practice of electric propulsion have received their largest measure of adoption, and where, we know, orders such as this would be no less welcome than to ourselves; and, second, that the prime movers will be Cammellaird-Fullagar Diesel engines, one of the very few all-British marine Diesel engines. We trust that this will prove to be only the first of many shipbuilding contracts to be placed in this country before winter again sets in.

The Protection of Metals from Oxidation at High Temperatures—(*Concluded from page* 284).

totally immune from any such action by these elements in the percentages met with in practice.

Calorizing has been successfully applied to the valves and valve seats for Diesel engines, and there would seem to be considerable scope for the process in this sphere. Inasmuch as it is only some three years since the process has been applied commercially to any appreciable extent, there are many further possible applications than have been considered in this brief article. With reference to the cost of the process, this is not heavy, having regard to the savings to be effected, both in the labour and material involved in renewals. It is claimed that the cost of calorizing a given article is in many instances actually less than the cost of a similar untreated replacement. The process is controlled in this country by The Scarab Oil Burning Co., Ltd., 28, Charles Street, Haymarket, S.W. 1.

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

Vol. XLV. No. 539. August, 1922.

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Mr. George Graham, of Freshfield, Lancs., for many years Manager of the Liverpool branch of the Donald Currie lines of steamers, who died in Edinburgh in March last, has left estate of the gross value of £49,827.

Vice-Admiral Sir George Goodwin, K.C.B., late Engineer-in-Chief of the British Navy, has been appointed a director of Richardsons, Westgarth & Co. Limited, engineers, Hartlepool, Middlesbrough and Sunderland, in succession to Capt. Walter Brown, R.N., who has resigned for health reasons.

The death took place recently in his seventieth year of Captain John Weatherill, director and founder of the firm of John Weatherill & Sons Limited, shipowners, Dublin. Deceased had been in the shipping business all his life, and was also agent for various lines.

Mr. Charles Butler, late Chief Inspector of the Outdoor Department of the Mercantile Marine Office, North Shields, has been presented with the Imperial Service Medal, on retiring after 37 years' service. Previous to entering the Mercantile Marine Office, he served 12 years in the Navy, and was present at the bombardment of Alexandria in 1882, and holds the Egyptian medal and clasp and the Star of the Khedive.

Mr. David Hunter, C.B.E., who died suddenly from pneumonia at Sydney, N.S.W., on June 29, was Chairman of McIlwraith, McEacharn's Line Proprietary Limited, of Melbourne, Australia. During the war he was Deputy-Controller of Coastal Shipping in Australia.

Captain W. J. Wade, General Superintendent of Markets under the Manchester Corporation, who has accepted an appointment under the Manchester Ship Canal Company in Australia in connection with food supplies shipped to Manchester, has been presented with an illuminated address and other gifts prior to leaving next month to take up his new duties.

The death occurred recently, at Calcutta, of Captain J. W. A. Ryan, who was for some time in the service of Lane & Macandrew Limited, shipowners, London, but in 1915 he went to Hong Kong and joined the firm of Jardine, Matheson & Co., and traded between that port and India. He was well known in shipping circles, was of genial personality, and had been a loyal member of the Mercantile Marine Service Association for over 30 years.

The Duke of Northumberland unveiled a portrait of Sir William J. Noble, Bart., the gift of the North of England Steamship Owners' Association in the Merchant Adventurers' Court, Guildhall, Newcastle, on July 13. The picture was given as some small recognition of Sir William's signal services as President of the Chamber of Shipping last year, and to mark his great work on behalf of the shipping industry over many years. The portrait is to be removed to London, and will adorn the Council Room of the Chamber of Shipping.

A presentation was made recently by Vice-Admiral Sir George Goodwin, K.C.B., R.N., at Richardson, Westgarth & Co.'s Hartlepool Works, to Mr. A. Keens on the occasion of his retirement. This consisted of £25, being the initial instalment of a grant of £125 which is to be paid to him over a period of five years. Mr. Keens is a retiring foreman. This grant is the first made under the benevolent fund scheme, which has just been inaugurated, and is a recognition of his loyalty and efficiency over 20 years in the service of the company. On behalf of the foremen, Mr. James Davidson presented Mr. Keens with a watch and Mrs. Keens with a silver epergne. Mr. Harry Goodchild, from the apprentices, presented him with a handsome walking stick.

Mr. R. J. Beveridge, Senior Surveyor to Lloyd's Registry of Shipping at Belfast, retired recently after 25 years' service in the port, much to the regret of all connected with the shipbuilding industry. Mr. Beveridge was altogether 33 years with the Society, having joined it from the service of the Peninsular & Oriental Line. He was educated at the George Watson College, Edinburgh, a school which has to its credit the distinction of having educated no less than six of the office holders in the present Government. On the occasion of Mr. Beveridge's retirement, an interesting function, presided over by Mr. Wm. Boyd, Managing Director of Workman, Clark & Co. Limited, took place in that firm's engineering offices, when a few friends presented him with a handsome gold watch suitably inscribed. Consulting engineers, superintending engineers and naval architects joined in the tribute, and speeches eulogistic of Mr. Beveridge's courtesy and ability were made by Mr. Boyd; Mr. H. M. Glass, General Manager; T. Moore, Engine Works Manager; J. C. Harding, Chief Engineering Draughtsman; and J. Wilkie, Assistant Works Manager of Workman, Clark & Co. Mr. Beveridge, in reply, referred to the harmonious relationships that had always existed between himself and his shipbuilding and shipowning friends in Belfast. He was leaving the city with sincere regret. Mr. Beveridge will be succeeded in Belfast in August by Mr. G. D. Ritchie from Grimsby.

EDITORIAL.

ELECTRIC PROPULSION FOR SHIPS.

CONSIDERABLE interest has been recently created—perhaps we should say revived—among engineers on the question of electric ship propulsion. Although this system cannot be described as new, inasmuch as several mercantile and naval vessels have completed varying periods of service with electric-propelling machinery in the last few years, there has been, nevertheless, a certain amount of conservatism among shipowners and engineers, so that only to a very limited extent has this method of propulsion been adopted in merchant ships.

We in this country have been more conservative than our friends in America, who, it must be admitted, have been responsible for by far the greater number of electrically-propelled ships. For the high-powered battleship or battle-cruiser it is claimed that the adoption of the electric drive eliminates certain very undesirable complications in the main turbines. Suitably geared cruising turbines which only operate when the speed and power have been reduced to a designed figure are no longer necessary. Economy of fuel consumption over a wide range of powers and speeds is made possible by the flexibility of electric transmission, and this economy is not only greater than that possible from reduced power in using turbines, but, it is asserted, has not yet been approached by any other system, having regard to the wide range of powers to be provided in naval vessels. Such considerations of economy are manifestly important to the United States navy which must provide for exigencies likely to require its operation at a considerable distance from home bases, and the adoption of this system of propulsion in successive American high-powered warships cannot fail to be regarded as something tantamount to a demonstration of superiority.

With the application of electric propulsion to mercantile tonnage we are, however, more immediately concerned, and elsewhere in this issue will be found reference to several merchant vessels so equipped. One advantage to which this system can lay claim, and we believe those opposed to the system will concede that it is an advantage, has reference to the fact that the driving agent, whether turbine, reciprocating-steam engine or internal-combustion engine, runs only in the one direction. By this means the astern turbine and complex pipe systems are unnecessary, and heavy reversing arrangements in the steam and internal-combustion engines are eliminated, with corresponding advantages. In the case of a turbine using superheated steam the absence of an astern turbine removes certain difficulties associated with the superheat question. Before embarking on the adoption of a new system of propulsion, the shipowner, in comparing it with other systems, is inevitably concerned with such questions as :—

(*a*) Initial cost.
(*b*) Weight and space occupied.
(*c*) Economy of operation, with reference to fuel and repairs.
(*d*) Sea-going reliability.
(*e*) Considerations of personnel.

Having regard to the limited number of ships fitted with this system, and to the natural diffidence manifested by the few shipowners on the question of costs, little information of an authoritative nature is available. Intrinsically, however, the electric system, with its power conversion and the considerable quantity of high-grade copper necessary, would seem *prima facie* to be expensive. On the question of weight and space occupied, this, within limits, may be influenced by questions of design. In the earlier electrically-propelled vessels, such as the *Walsty Castle* and *Biyo Maru*, as illustrated in this issue, not only were the motors placed amidships, but single-reduction mechanical gearing was also introduced between the motors and the propeller. In the *San Benito*, some particulars of which we publish on page 320, no gearing has been incorporated and, by placing the motor aft, a certain amount of space is presumably saved by the elimination of the shaft-tunnel from the after holds.

As compared with the double-reduction geared turbine it is to be doubted whether the electric system introduces additional economy. Commander Robinson, U.S.N., in his recently published book "Electric Ship Propulsion," gives for the U.S.S. *Jupiter* coal consumptions of 1·662 lbs. per s.h.p. for 14·99 knots, and 2·5 lbs. per s.h.p. for 10 knots. Although these figures do not constitute much, if any, advance on ordinary practice, it is to be assumed that more economical results are now possible in the light of the experience gained since that vessel was equipped. Taken as a whole, and having regard to the experience actually gained in merchant vessels at sea in all weathers, there would appear to be sufficient reason for regarding electric propulsion as having reached a comparatively high standard of reliability. Opinions are divided as to whether the main motor should be placed right aft or in the more accessible main engine-room where its performance is under constant observation. Objections have been raised in certain quarters that, in view of the complex electrical equipment, combined with the steam or internal-combustion engine, until such time as marine engineers have been trained to a higher degree of proficiency in electrical matters, questions of *personnel* are likely to militate against its employment. Such, however, is our belief in the resourcefulness and receptive mentality of our marine engineers that we do not regard this as a serious obstacle.

The experience gained by the United Fruit Co., of Boston, with the electrically-propelled *San Benito* during the last year, and their recently placed order with Cammell Laird for three Diesel-electric insulated fruit-carrying steamers, constitute what is undoubtedly the greatest fillip so far given to the development of the electrically-propelled merchant ship. The economy of the Diesel engine has been already established, and allied to the flexible electric drive, this attractive combination will be followed with the closest interest.

NAVAL ARCHITECTS IN PARIS.

THE summer meetings of the Institution of Naval Architects which were held in Paris during the early part of this month mark the first occasion on which these meetings have been held abroad since sometime previous to the war. Viewed in retrospect, the various meetings, social gatherings and visits to places of interest were, by general consent, a great success, and to the capable organisation of Mr. Dana, the secretary, and in no less measure to the splendid hospitality of our French friends, much of this success is due. Apart from the purely technical aspect of meetings such as these, the wider social sympathies engendered by the co-mingling and exchange of ideas as between intelligent business and academical representatives of Britain and France, following, as they have done in this particular case, a period during which each of the two countries has not always appreciated the other's viewpoint, cannot fail to have a wide and beneficial influence on the international relations.

As was inevitable the present depressed state of the shipbuilding and engineering industries had its distinct reflex on the character of the several papers read at these meetings. While the papers in themselves contained much of technical merit and interest it must be admitted that to the Transactions of the Institution there have been added, in the past, papers which, viewed as a series, have a greater claim to be regarded as authoritative contributions to naval architectural progress. To a certain extent of course the prevailing conditions in the industry are responsible for this. The problems arising out of the war and its aftermath, and the naval position created by the recent Washington Conference, provided considerable scope for discussion, and the opening papers by

Sir Eustace d'Eyncourt and Major Fea were distinctly appropriate. Sir Eustace discussed the question of the development of war vessels with reference to the experience gained during the war, and in the discussion which followed there was ample evidence that naval architects are fully cognisant of the new problems facing the designer, having regard to the tonnage limitations imposed at Washington. On the question of stability it would appear that there is still new ground to be covered. Sir John Biles, introducing his paper dealing with the stability of large ships, pointed out that the primary object of the paper was to promote discussion, and to those present it was abundantly evident that this object had been fully attained. The present year has seen more than one ship capsize which has been apparently well designed, and Sir John's paper is therefore timely. Sir Westcott Abel suggested that some standard form of stability calculation should be introduced somewhat on the lines of the present standard strength calculation. Professor Hillhouse raised a point of considerable practical importance in directing attention to the tendency of shipowners—whose idea was that there was "plenty of room at the top"—to introduce additions to the upper structure of the ship during building, so that the final centre of gravity was not always that originally projected. Failure on the part of the ship's *personnel* to exercise the necessary judgment in the disposition of water ballast or during bunkering operations has frequently been the cause of a dangerous condition of instability and there would seem to be need for rendering a vessel as far as possible proof against such errors in judgment. A point which Mr. Lovett's paper and the discussion on the proportions and block coefficients of merchant ships served to demonstrate, was the lack of a common or international system of units. Given such a standard system, the value of the vast amount of experimental data, being expressed in terms of standard units would, it seems reasonable to believe, be considerably enhanced.

Professor Guillet's paper, dealing with the testing of shipbuilding materials, and that of General Rota, describing launch experiments with contrary-turning co-axial screw propellers, are productive of considerable interest to marine engineers. We publish abstracts of these papers elsewhere in this issue. The latter paper is of some interest at the present time in view of the experiments recently carried out by Denny Bros., of Dumbarton, on a vessel of 100 ft. in length, fitted alternately with twin-screw propellers and vane wheels. It was demonstrated, as a result of these trials on the Clyde, that the vane wheel method of propulsion gave the same speed as that obtained with immersed screw propellers but with a saving in shaft horse-power of no less than 41 per cent. The discussion on General Rota's paper showed that although a slightly higher propulsive efficiency was apparently obtained as described, yet such increase in efficiency might more simply have been attained by modifying the original propeller. We are disposed to agree with Sir Archibald Denny that, when the high efficiency of 70 per cent. is obtained, the practical value of an additional efficiency of some 3 per cent. at the expense of more complex machinery arrangement is open to question. Professor Dalby, discussing the testing of materials, demonstrated the value of optical tests and M. Doyère pointed out that the constant value of the elasticity modulus denied to naval constructors the use of the higher tensile properties of the newer steels. Having regard to the importance of this branch of the industry as indicated by the title, and inasmuch as the scantlings of ships are fundamentally dependent on the strength properties of materials, it would be a matter of interest to learn the views of the principal classification societies.

Summing up, it may be said that the recent meetings were more of a social than a strictly technical nature, the outstanding feature of the conference being the fine spirit of comradeship and cordial hospitality manifested by the French representatives and authorities. No better augury for the success of future meetings of a similar nature, but, we hope, under more prosperous industrial conditions, could be desired.

THE MEASUREMENT OF CONDENSER PERFORMANCE.

THE extent to which the steam turbine is used at the present time for the propulsion of ships makes the problem of efficient condenser design one of the greatest importance. It is generally recognised by marine engineers that the best results from a steam turbine can only be obtained when the steam is allowed to expand to the lowest possible pressure before passing through the exhaust to the condenser, and hence, on turbine ships, it is customary to install condensers which are capable of producing a higher vacuum than is the case on ships fitted with reciprocating engines. The production of an extra half-inch in the condenser vacuum will result in a large increase in the power developed by the turbine, and it has become the practice to run the condensing plant on turbine ships so that the vacuum approaches to within about 1 in. of barometric height, or, on an average, to about 29 in. of mercury, while on vessels fitted with reciprocating engines, a 26-in. or 27-in. vacuum was generally considered as representing the limit above which it was not economical to proceed.

Considering the condensing plant as comprising the condenser itself with merely its circulating pump and air pump, an increase in the vacuum can be obtained by increasing the size of the condenser or by fitting a larger air pump when dealing with a given quantity of exhaust steam. Merely increasing the size of the circulating pump tends to lower the temperature of the condensate with corresponding loss of efficiency of the boiler; although in dealing with a larger condenser a correspondingly larger circulating pump will of course be required. Hence, to produce a higher vacuum, we shall be faced with a larger expenditure of steam in both the air pump and the circulating pump, and the question arises as to how far these increases can be met before the saving in consumption in the main turbine is balanced by the increased consumption in the condenser auxiliaries. In addition to the factor of steam consumption, there is also the question of the increased weight and cost of the plant to be set against the saving in the cost of running it, and this is a point which must not be lost sight of when dealing with the increase in the size of auxiliary machines for any particular purpose.

Although no definite data are available as to when the simple condensing arrangement referred to above ceases to be economical, it is realised that in the production of high vacua some additional means must be adopted. There are many systems of producing a high vacuum which have been tried in conjunction with turbine installations on board ship, and all of them achieve a certain measure of success. In one system we have what is termed an augmenter condenser by means of which the vacuum obtained in the main condenser is still further increased. In another system we have two air pumps, one connected to the bottom of the condenser and one to the top, and known respectively as the wet and dry air pumps. Yet, again, we have systems in which rotary pumps are employed in preference to reciprocating pumps, while there are many devices in which the exhausting effects of jets of either steam or water are employed in order to reduce the pressure in the main condenser. All these systems, as we have already said, succeed more or less in their object of producing a high vacuum, but it is very difficult to say at what expense in steam consumption this vacuum is obtained, and in any case the superintending engineer who is desirous of forming an opinion as to the relative merits of the different systems with which he is confronted, is at a loss to find a common basis from which the systems may be compared.

The growing importance of the steam turbine for merchant ship propulsion and the consequent demand for condensing plant capable of yielding high vacua, renders it almost imperative that some means of expressing the efficiency of the performance of condensing apparatus should be devised.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Modern Practice in Heat Engines. By Telford Petrie, M.Sc., A.M.I.C.E., A.M.I.Mech.E. London: Longmans, Green & Co., 39, Paternoster Row, E.C. 4. 5¾ in. × 8½ in. × 1¼ in. 264 + xi pp. and 2 folding plates. Price, 15s. net.

This book is intended as a companion to the late W. Inchley's "Theory of Heat Engines" and, as the title indicates, treats more particularly of practice than theory, although the methods of application of theory to the design of modern types are dealt with. In the first section practically every type of steam boiler is illustrated and their more outstanding features are briefly described. The treating of such a wide subject as modern boiler practice in the brief compass of this section, and the large amount of generalisation attempted, have introduced difficulties which are at once manifest.

In the section on Steam Turbine Design and Practice, the author has drawn on the lectures of Prof. G. S. Stoney, D.Sc., F.R.S., and this, we feel, constitutes the best section of the book. The section dealing with Internal Combustion Engines describes more particularly the smaller types of gas and oil engines, and in the light of recent developments in large-powered Diesel engines it is felt that more extended reference to this aspect of the subject might have been made. The method of treatment throughout is good, and to the reader in search of a brief treatise on the practical application of the principles of thermodynamics the book is to be recommended.

Notes and Sketches on Marine Diesel Oil Engines: A Manual of Marine Oil Engine Practice. By J. W. M. Sothern, M.I.E.S., M.I.Mar.E. Glasgow: James Munro & Co. Limited, 35-37, Washington Street. 9½ in. × 6¼ in. × 1¼ in. 400 pp. Price 25s. net. Numerous illustrations.

The author of this book needs no introduction to marine engineers, among whom, both in this country and abroad, his numerous publications are widely read. As in his other books relating to marine engineering, Mr. Sothern has produced many folding plate, black and white line drawings and sketches which are altogether excellent. Primarily intended as a text-book for the Board of Trade Examinations for Motor Certificates and Endorsements, this work will be particularly welcomed by candidates for these examinations. No claim is made to treat of the higher and complex theory associated with Diesel engine design, but as a purely practical work which takes account of every consideration governing the operation and maintenance of Diesel and other internal-combustion engines, the book is a model of simplicity and clarity. Questions and answers relating to Diesel engine practice are clearly set out in simple tabular form, a section is devoted to the testing and general characteristics of fuel oils and the several instruments used are illustrated and described. A further section gives a series of practical calculations, both in the British and Metric systems. This is a work of real practical merit, and to the Board of Trade candidate it will, we feel, prove almost a *sine quâ non*. To the superintending engineer directly concerned in the operation of Diesel tonnage or to others interested in the development of the Diesel engine we can safely recommend this book.

"The Journal of the Institute of Metals." Volume XXVII. Edited by G. Shaw Scott, M.Sc. 1922. London: Institute of Metals, 36-38, Victoria Street, S.W.1. 5½ in. × 8½ in. × 1½ in. 621 + viii pages, numerous plates and figures. Price 31s. 6d. net.

In this, the latest volume of the Institute of Metals, the new President, Mr. Leonard Sumner, O.B.E., M.Sc., in his inaugural address, urges the importance of the Institute to the manufacturer. The first 300 pages are devoted to a discussion on such practical problems as the corrosion and season cracking of condenser tubes, recrystallisation of cupro nickel, failure of aluminium alloys, &c., while the latter section is devoted to concise abstracts of hundreds of metallurgical papers published in all parts of the world during the last few months. This is a volume of high scientific value and importance to every engineer and metallurgist.

"Engineering Workshop Handbook." Fifth Edition, 1922. By Ernest Pull, A.M.I.Mech.E., M.I.M.E. London: Crosby, Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill. 4 in. × 6⅞ in. × ½ in. 175 pages, numerous illustrations and tables. Price 3s. 6d.

The favourable reception accorded the fourth edition of this book led the author to proceed with a fifth edition, which has embodied two additional chapters on Precision Grinding and Tapers and Taper Turning, respectively. To the youth who is about to embark on an engineering career a perusal of this work will be particularly helpful and will furnish beforehand much information of a practical nature which will enable him to grasp the more readily first principles. In the preliminary chapters a sound practical discussion of workshop arithmetic and mensuration is given, supported by examples, while the various workshop operations and tools are clearly described and illustrated. The journeyman, the improver and the apprentice will find this book a source of practical enlightenment and encouragement, and its compact nature renders it an admirable workshop auxiliary.

TRADE PUBLICATIONS.

Impulse Turbines.—We have received from The English Electric Co. Limited, Kingsway, W.C.2, an illustrated catalogue containing photographs, drawings and graphs describing their Seewer governing device for hydraulic impulse turbines. The device consists of a series of blades fitted in the nozzle whereby the circular section of the jet is broken up and the energy diverted from the buckets.

Metallic Packing.—The Combination Metallic Packing Co. (1921) Ltd., of Gateshead-on-Tyne, have just issued an illustrated list showing their standard sizes of C.H.H. type Metallic Packing for saturated or superheated steam.

Hydraulic Presses:—Owing to a typographical error in the notice appearing under this heading in our July issue, the average size of bale produced by the standard press as manufactured by Hollings & Guest Ltd., Thimble Hill Lane, Birmingham, read 2 in. × 15 in. × 6 in., instead of 27 in. × 15 in. × 6 in.

Osglim Discharge Lamps.—The General Electric Co., Magnet House, Kingsway, W.C.2, have published an attractive series of leaflets and folders illustrating the Osglim lamp as manufactured at the Osram General Electric Co.'s Works, Hammersmith. These lamps, introduced some 12 months ago, have rapidly found favour for use as night-lights, as indicators and for advertising purposes. A new feature is a lighting type lamp in a ruby varnished bulb for use in photographic dark rooms. A novelty show card, depicting a night nursery, has also been produced. This card is in the form of a collapsible model and is designed for illumination by an Osglim lighting type lamp.

THE PROBLEM OF THE INTERNAL COMBUSTION TURBINE.

Comparison of temperature conditions in the Internal Combustion Turbine and the Reciprocating Engine—Practical conditions—Internal Combustion Turbine a possible economic intermediary between Steam and Diesel Engines.

There is little doubt that of all the developments in marine engineering which the immediate future holds in store the solution of the problem of the internal combustion turbine may be regarded as one of the most important, if not, perhaps, as one of the most likely, for it is not to be denied that the difficulties involved are still considerable. While the reciprocating marine oil engine as at present constructed cannot by any means be regarded as a final solution of the proper method of making use of the potential energy in oil in a self-contained prime mover, the essential features of the large Diesel engine—to use a generic term—do admit of the utilisation of temperatures and pressures which it has not yet been found possible to adopt in other designs such as rotary engines, and they do provide, in the way of thermal efficiency related to shaft horse-power, results superior to those obtained with any other form of engine. Nor is it to be denied that there is still considerable room for improvement in the efficiency of the Diesel type. One great step has been made by Scott & Co., of Greenock, who have proved that they can obtain a shaft horse-power for about 0·36 to 0·38 lb. of oil per hour with their single cylinder Scott-Still experimental engine. It is true that this is accomplished only at the cost of a much higher and more expensive installation, but it constitutes a record in the way of high thermal efficiency. Another step which may prove of far-reaching importance is being tried in the United States, where a compound internal combustion reciprocating engine has already been subjected to extensive tests. Excluding the latter, which is even less developed than the internal combustion turbine, of which numerous experimental sets have been constructed at one time or another, the Scott-Still principle would appear to be the only real improvement in the reciprocating oil engine from the point of thermal efficiency—not from that of durability or reliability be it understood—which has been made for several years, and even to-day the initial and final temperature limits between which the engine works show virtually no advance over those obtained in the first large ocean-going motor vessel. Whether the engine be a two-cycle or a four-cycle design, the positive work of the explosion ceases when a crank-angle of about 160 degrees has been reached, though the pressure in the cylinder is still some 40 lb. per square inch and the Fahrenheit temperature some 1,000 deg. The rejection of heat into the atmosphere is thus considerable. Following on the lines of the steam turbine, it is confidently anticipated that use can be made of the heat still remaining in the gas if the turbine form of prime mover be employed, and the quantity which is thus available represents an increase, depending on the final temperature, of anywhere between 20 and 40 per cent. The sub-atmospheric working which has often been advocated might be feasible were it not for the fact if oil is to be the source of power it must be possible to use various kinds, and the almost universal presence of sulphur is apt to result in a combination with the condensed H_2O in the gas at the low-pressure end when the temperature is reduced below 212° Fahr., with the result that sulphuric acid will be formed.

Difficulties to be Overcome.

The difficulties which have hitherto baffled designers of internal combustion turbines have been as follows :—

(1) The temperature of the gas entering the turbine and impinging on the blades is excessive for a constant admission. It is permissible in the Diesel design on account of its very momentary application.

(2) The very high speed of the gas flowing through the nozzle necessitates a correspondingly high turbine vane speed, which again involves high revolutions, and until the introduction of gearing these were far too high to admit of the internal combustion turbine even being considered for marine work.

(3) The negative work of compression has hitherto proved a stumbling block owing to both the inefficiency of external compressing arrangements (as opposed to compression in the working cylinder of a Diesel) and to the fact that in the gas turbines built up till the present time the efficiency of the positive end was also low. The negative work of compression, therefore, formed too great a proportion of the ahead work.

(4) A satisfactory design of gas turbine, particularly for marine work, must be capable of being readily started, stopped and manœuvred, and control valves working under very high temperatures and pressures are by no means easy to design.

Each of these fundamental difficulties brings a number of others in its train, so, for a complete working solution, it must be understood that a very large amount of careful thought and study is required.

In the diagram on page 298 are plotted, on a base of percentage of cylinder volume, plus clearance volume, curves showing the temperature and pressure throughout the working stroke for a 200 h.p. Diesel land engine and for the motorship *Suecia*, built by Burmeister & Wain some years ago. A glance at these will show for what brief duration does one cylinder have to withstand the maximum pressures and temperatures. The curves of the latter are interesting as in each case they indicate a distinct degree of incomplete combustion at the end of the stroke, which results in additional loss of heat rejected to atmosphere. In a gas turbine this source of loss will not occur; even if the combustion on explosion is not complete it will become so during the passage through the blading. Pressures higher than those employed in steam practice are only present for about one quarter of the stroke. Now, while the pressure in the gas turbine can be varied by a judicious arrangement of the volumes throughout the machine, it is otherwise with temperature.

Considerations of Pressure, Volume and Temperature.

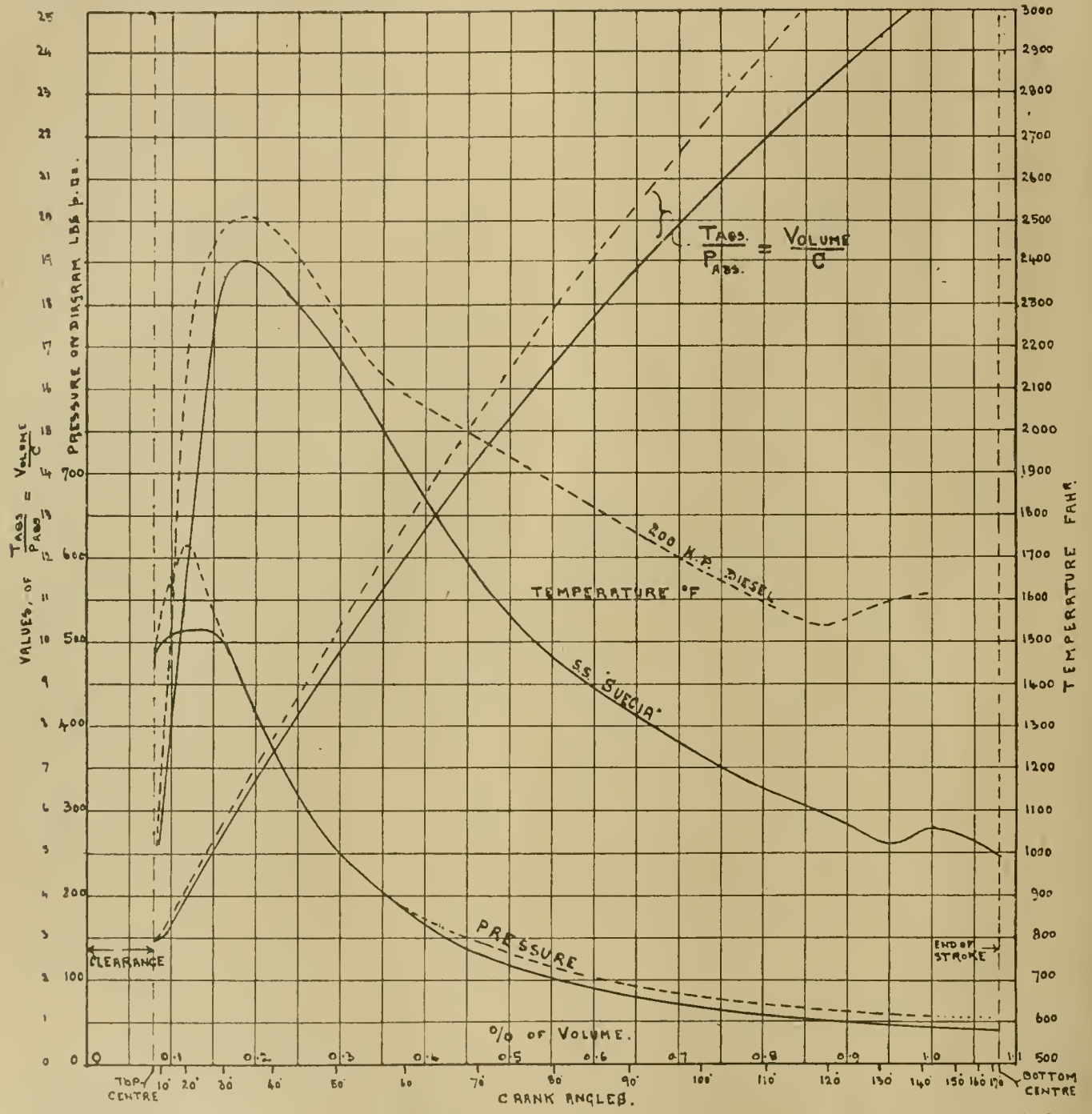
The expression connecting these factors in the case of a perfect gas is written—

$$PV = TC$$

where C is constant, having different values for different gases, and T is absolute temperature.

Thus, for air C = 53·75, for oxygen = 49·79, for nitrogen and CO, 55·23, and for CO_2 = 35·01. Unlike steam, for which every pressure possesses a definite temperature and volume per pound, gas mixtures vary considerably. Not only do the compositions vary, but the proportions of excess air over and above that required for complete combustion may differ widely. Calculations, therefore, require to be based on an assumed quality of oil and an excess air factor estimated from oil engine practice. If the quality of oil be arbitrarily modified and a different ratio of excess air be assumed, the proportions of the plant which result from a detailed calculation will be found to differ considerably, and the designer is thus faced with a very laborious task in calculating a new design. Pending

experiment, the only satisfactory method is to choose the percentage carbon and hydrogen contents and an excess air factor and stick to them. In working out the details of an internal combustion turbine design, the volumes of gas to be handled will be found surprisingly small compared with those of steam and the ratio of expansion very much less than is the case where the fluid is condensed. The result is that the low-pressure end of a gas turbine will require a lower blade speed than the high-pressure end if the best utilisation of the energy in the fluid is to be obtained. The turbine itself really presents comparatively few difficulties; it is the compression and the admission of the gas to the turbine that has so far proved insoluble. Most inventors, and the few constructors of actual turbines, have contented themselves with a separate and externally driven compressor, and while it does not seem logical to adopt a reciprocating compressor for assisting in the generation of the motive fluid for a rotary engine, no solution in the way of a rotary compressor seems feasible in view of their low efficiency. One suggestion has been to devise a kinetic compressor operated by the exhaust gases for generating the mixture; electric firing would be required on account of the low temperature. The turbine requires practically a constant flow of gas: how then is the problem of the initial high temperature to be solved?



Temperature and Pressure Curves for 200 H.P. Diesel land engine and for the 2,000 H.P. engines of the Motorship "Suecia."

Alternative Solutions of Temperature Problem.

Two ways at once suggest themselves:—

(*a*) The use of special material, and

(*b*) The sacrifice of initial temperature even at the loss of efficiency.

If it is eventually found too difficult to provide (*a*), does the solution of reduced efficiency appeal sufficiently strongly ?

The answer may be given as follows :—It is quite clear that a gas turbine can be made to work if the extreme temperatures used in the Diesel are not employed, and use can be made of much lower temperatures at the exhaust end. Even supposing that the consumption of a large oil engine is materially less than that of the gas turbine when the latter is working under conditions that do not introduce some of the major difficulties associated with high pressure and temperature, it does not follow that there is no scope for the latter by any means. The marine Diesel engine after all is of quite limited application. Eminently suited to a large class of slow-speed ocean-going vessels, it is limited to those in which the weight can be devoted to it or to those whose aggregate power is within its scope, whereas the turbine can be made to develop any power when once the difficulties recorded above can be overcome. Even if the internal-combustion turbine prove to be a less efficient prime mover than the reciprocating motor, always provided that its thermal efficiency is greater than that of a steam set, there must be enormous scope for it in view of its advantages in weight and space required.

The most economical steam plant in the world is probably the Carville No. 3 Station at Wallsend-on-Tyne. On test, the thermal efficiency of the Parsons 10,000 kw. turbines installed there was 25·0, and that of the boilers about 80, giving an overall efficiency of 20 per cent., which in practice, for the year 1920-21, was reduced to 17·75 per cent. The next two most efficient land generating stations in Great Britain did not exceed 15·0 per cent. thermal efficiency. Scott & Co. have exceeded 36·0 per cent. in the course of the trials of the Scott-Still experimental engine, and may be relied on to improve this materially. The average marine installations may run from 12 to 16 per cent. It will be seen, therefore, that the internal-combustion rotary engine may offer opportunities of very considerable saving without nearly approaching the economy of the heavy oil engine because it is applicable to cases in which the latter is not suitable.

We understand that work which is now in progress in this country has gone no inconsiderable way towards indicating that, although there are still difficulties to be overcome in producing an entirely satisfactory gas turbine, these are very unlikely to prove insuperable. It is impossible to overlook the comparatively recent history of the steam turbine which has been one long record of improvement ever since the satisfactory experience with the first commercial steamer just 21 years ago.

BURMEISTER & WAIN'S MACHINE SHOP EQUIPMENT.

The very great progress made in the development of the Diesel engine during the last few years has not unnaturally called for improved constructional equipment, and in this issue we publish some illustrations, and the following brief description of some of the more recent developments at the Copenhagen works of Burmeister & Wain.

We show on page 302 a general view of the main erecting shop where several Diesel engines will be seen in various stages of construction. The main dimensions of this shop are :—

Length	90 m. (295·2 ft.)
Breadth	29 m. (95·1 ft.)
Height (from floor to crane hook)	12 m. (39·38 ft.)

This shop is served with three overhead travelling cranes, two of which have a capacity of 50 tons and the third of 30 tons. The principle of line production has been adopted and the situation of the several other shops in relation to this erecting and testing shop is such that each item of machinery, as it passes through the various stages of manufacture, gradually and automatically progresses towards the erecting shop. On page 303 we show photographs illustrating a crankshaft milling machine and a super-milling and boring machine. The latter machine constitutes a most important and useful item in the extensive manufacture of Diesel engines carried on at Copenhagen. Situated at the end of the erecting and testing shop the machine is capable of accommodating the largest castings made. The following main dimensions of this large milling and boring machine may serve to convey some impression of its size :—

Weight	500 tons.
Cutting length	10 m. (32·8 ft.)
„ height	4 m. (13·12 ft.)
Distance between cutters on the towers	4 m. (13·12 ft.)
Diameter of spindle	325 mm. (12·8 in.)
Diameter of cutter up to	600 mm. (23·6 in.)

As will be seen the machine comprises two large towers, and for the power necessary to drive the tower spindles a 50-h.p. electric motor is fitted for each tower. The towers are moved longitudinally by a 20-h.p. electric motor—one for each tower. The spindle carriage on each tower is raised or lowered by means of an 8-h.p. motor. By the provision of the great cutting length, engine parts can be machined at one end while additional work is proceeding simultaneously at the other end. Moreover, with the great distance between the towers, it is possible to machine the largest Diesel engine castings at two opposite surfaces simultaneously, thereby ensuring parallel work. It is also possible to machine surfaces at any desired angle.

The crankshaft milling machine is shown with a four-throw shaft in place ready for machining. A special feature of this machine has reference to the turn-plate or table to which the lower end of the shaft is fixed. The shaft is capable of being lowered into a pit under the machine to such depth as the length of the shaft and the nature of the work may require. The only practical limits to the capacity of this machine are the height of the roof and the depth of the pit, limits which are, of course, capable of considerable extension.

Both of these machines were designed by Mr. Overgaard, and were built by Burmeister & Wain themselves, which is yet a further demonstration of the firm's enterprise. It has been estimated, with reference to the first of these machines described, that, assuming 300 working days per year and 8 working hours per day, its annual capacity for machining heavy engine parts is about 12 twin-screw installations, each installation being of about 4,500-h.p.

Diesel Engine Orders.—Some short time ago we announced that Harland & Wolff Limited, who hold the sole licence for Britain and the Colonies for the construction of Diesel engines on the Burmeister & Wain system, had granted to the old-established firm of John G. Kincaid & Co. Limited, Greenock, a sub-licence for the construction of this type of internal-combustion engine. Recently, Kincaid & Co. entered into a further arrangement with Harland & Wolff for an extension of the licence to enable them also to construct this type of machinery for export to Spain, France and the French Colonies. We are now informed that Kincaid & Co. have secured an order to supply a set of six-cylinder Burmeister & Wain-Harland & Wolff type of Diesel engines, capable of developing 1,350 b.h.p., for a new vessel to be built on the Clyde for British owners. They have also been successful in obtaining an order for another set capable of developing 1,900 b.h.p. This latter set, we understand, is for a leading firm of Spanish shipowners, and on completion the machinery will be shipped to Spain where it will be installed in a ship building there. It is interesting to note that this will be the largest set of Burmeister & Wain-Harland & Wolff single-screw Diesel engines of the long stroke crosshead type yet constructed in this country.

THE SCOTT-ROSS WATERTIGHT DOOR FOR SHIPS' BULKHEADS.

An Electrically-Operated Watertight Door—Patent Magnetic Clutch—Arrangement of Controls.

Prior to the findings of the International Conference on the Safety of Life at Sea, which required that in passenger ships containing more than five watertight doors at the stokehold level these should be mechanically controlled, such provisions were only voluntarily adopted by a few of the more enterprising shipowners. The findings of that Conference were subsequently amplified by the British Government, and in their extended

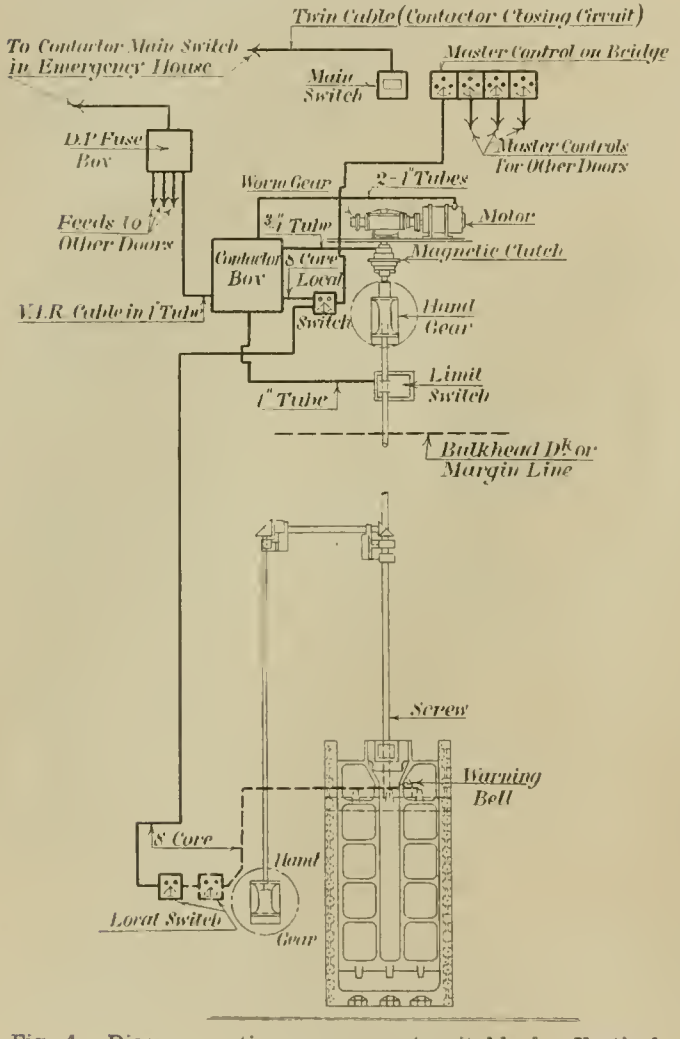


Fig. 1.—Diagrammatic arrangement suitable for Vertical Watertight Door.

form required that all ships carrying 200 or more passengers should have watertight doors capable of positive control from the navigating bridge, in addition to the usual station at the door itself. With a view to arriving at a different arrangement from the hydraulic system the Scott-Ross electrically-controlled system was devised, and this system is illustrated in Figs. 1, 2, and 3.

In Fig. 3 will be seen the general arrangement of the power unit and controls which, it should be noted, are situate *above* the bulkhead deck. The operations of opening and closing the door are effected by a triple pitch square screw or screws cut on a rotating shaft working in a nut contained in a box which is cast with the door itself. The thrust on the shaft is taken by ball thrust collars and the shaft is extended with journal bearings at suitable intervals from the door to a position above the highest floodable level. The hand gear takes the form of cranks or wheels and is always connected positively to the shafting through bevel pinions. It is thus ready for instant use at all times without the necessity of any preliminary adjust-

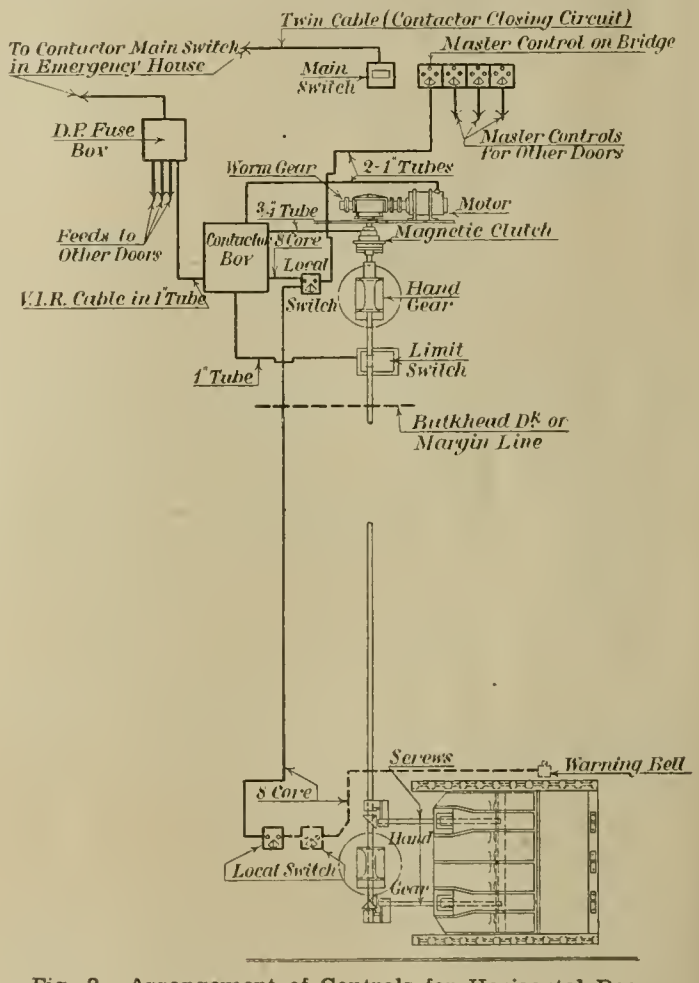


Fig. 2.—Arrangement of Controls for Horizontal Door.

ment of pins or clutches, and one set of hand gear is always above the bulkhead deck, as illustrated in Figs. 1 and 2 which show alternative arrangements for vertical or horizontal watertight doors respectively.

The electric motor is series wound, having a few shunt turns to limit "no load" speed, with worm reduction gear controlled by the simplest possible contactor switches without any starting resistances. A special feature of the control gear is the provision of a patent magnetic clutch which connects the power unit to the operating shaft. This special clutch has greatly contributed towards the simplicity of the control gear, and is so connected in the electrical circuit that it functions automatically. When the current is switched on, the motor starts without load, but when it has attained about one-third of its full speed the clutch automatically operates and connects the

door shafting, thus securing the essential feature of a momentarily large torque, or blow, to start the door from rest. The length of the operating shaft gives a degree of flexibility and resilience which prevents undue shock. When the current is switched off the clutch automatically disconnects the power unit, thus leaving the hand gear free to be operated as desired. A special limit switch is provided which automatically cuts off the power at the open or closed positions of the door, and this switch is situate near the power unit and above the flooding level.

Any number of control stations may be employed, but in practice the general rule is four, viz.:—one on the navigating bridge, one at each side of the door on the bulkhead, and one alongside the power unit. A system of indicators has been devised which facilitates the operation of the controls and tends to render the working of the apparatus fool-proof. These indicators are combined with the control switches at each station, where red and green lamps indicate "closed," "open," or "intermediate" position of the door and indicate whether power is available. A blue lamp is fitted to the master control on the bridge to indicate when the overload has opened as the result of a jamb, either in the closing or opening operation. An alarm system of electric bells or hooters gives warning when the doors are in motion.

This gear is supplied by Scotts Shipbuilding & Engineering Co. Limited, Greenock, and several vessels have already been fitted with this system of control which has passed the highest requirements of the Board of Trade.

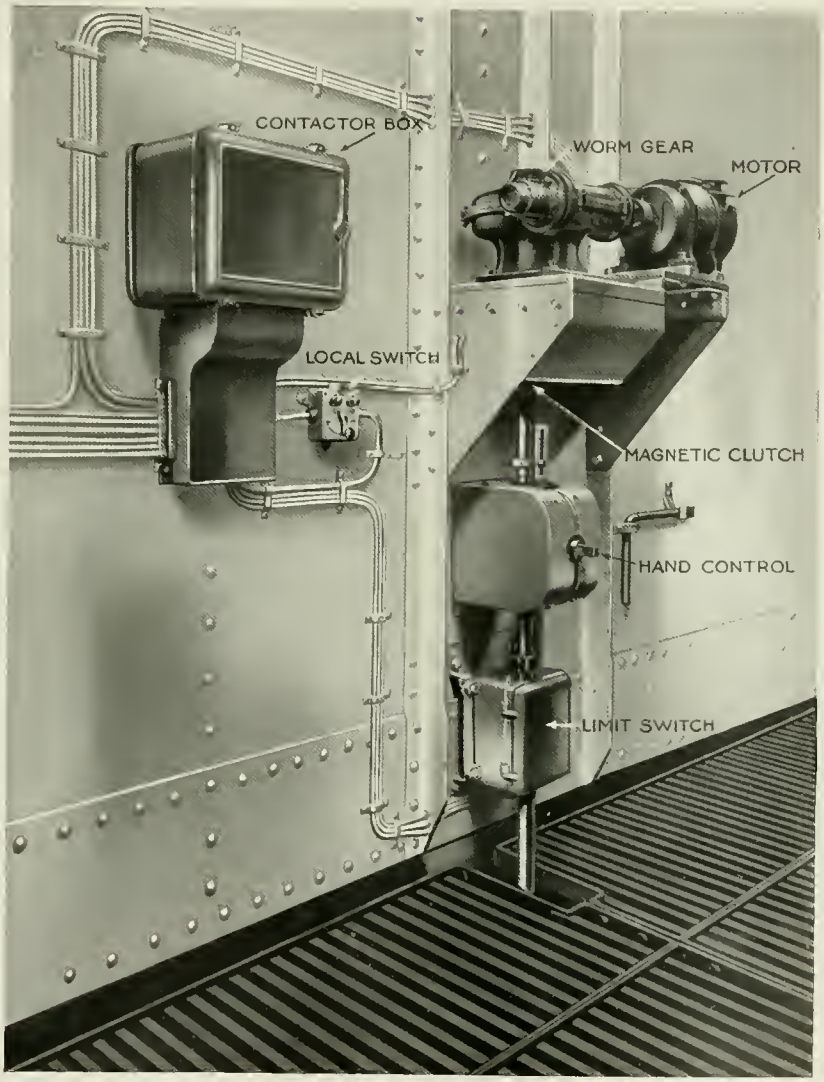


Fig. 3.—Arrangement of Power Unit and Controls above Bulkhead Deck.

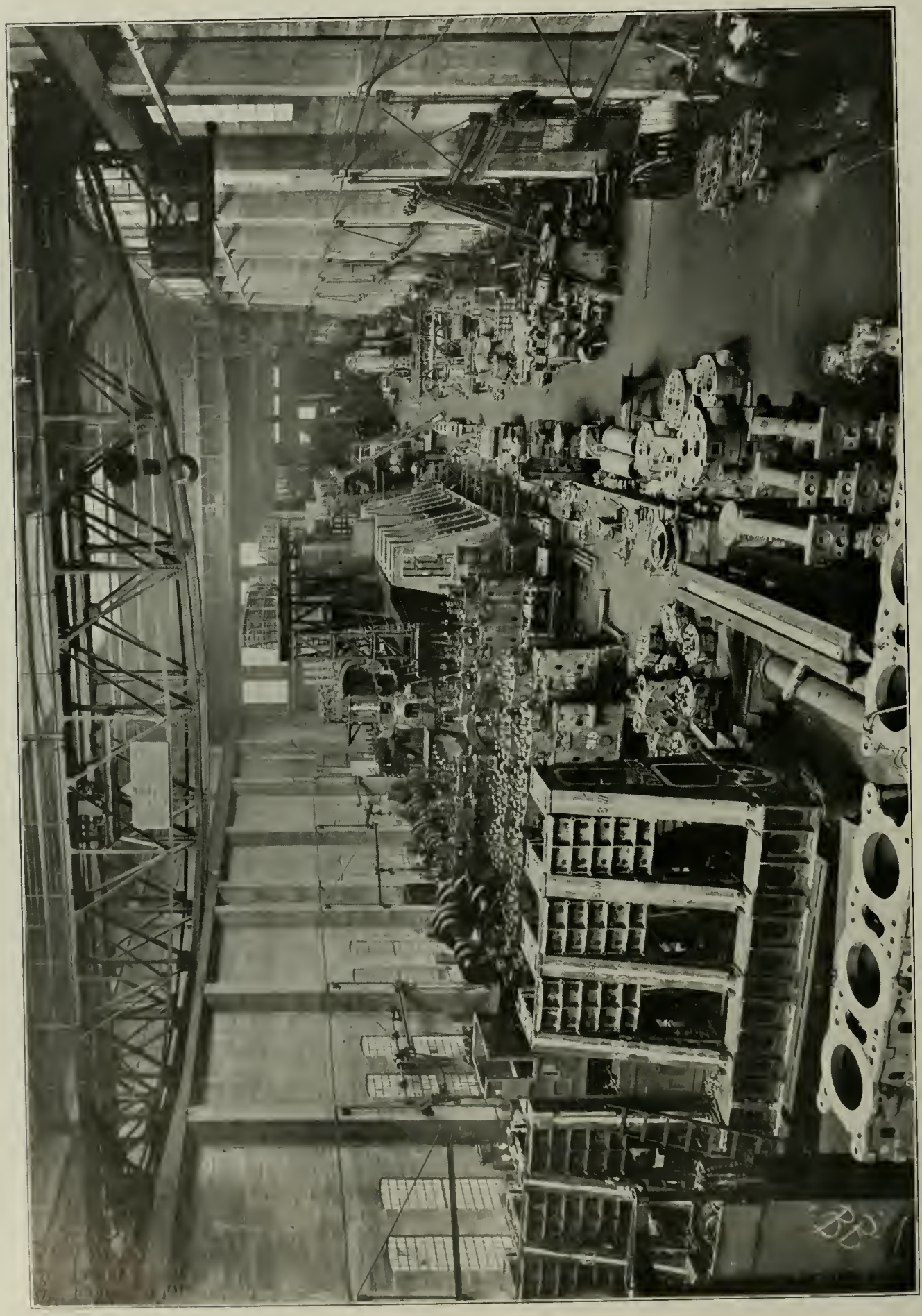
THE NEW RULES OF LLOYD'S REGISTER OF SHIPPING.

At a special meeting of the General Committee of Lloyd's Register Society, held on July 13, revised rules for the construction and classification of steel ships were approved and adopted. The new rules will come into force at the expiration of six months from that date, but they may be adopted at once, with the sanction of the owner in the case of any vessel contracted for, or which may be contracted for, before that date.

The last revision of the rules was made in 1909, when the number of types of vessel for which provision was made was reduced to the Full Scantling Vessel and the Shelter Deck Vessel. Experience has indicated that it is possible to make freeboard assignment independent of type, with the consequence that, in the new rules, the relation of scantlings to draught has been definitely taken into account for the first time. The result is the abolition of what may be termed "type" classification, and the new rules may thus be said to complete the work commenced in 1909, bringing them into line with modern practice and the most up-to-date ideas of shipbuilding. Sets of tables for two classes of vessel are provided, viz.:—(1) the full scantling vessel, which obtains the maximum loading permitted by the dimensions; (2) the complete superstructure vessel, in which the scantlings are adjusted to a freeboard approximate to that of the present shelter-deck type with tonnage opening. Scantlings for vessels intermediate in draught between these two types can be readily derived from the two standards by proportional interpolation. By this system the new rules are directly applicable to practically the whole range of vessels suitable for modern requirements, and it is thought that designers and builders will obtain greater elasticity in adjusting deadweight and capacity for cargo.

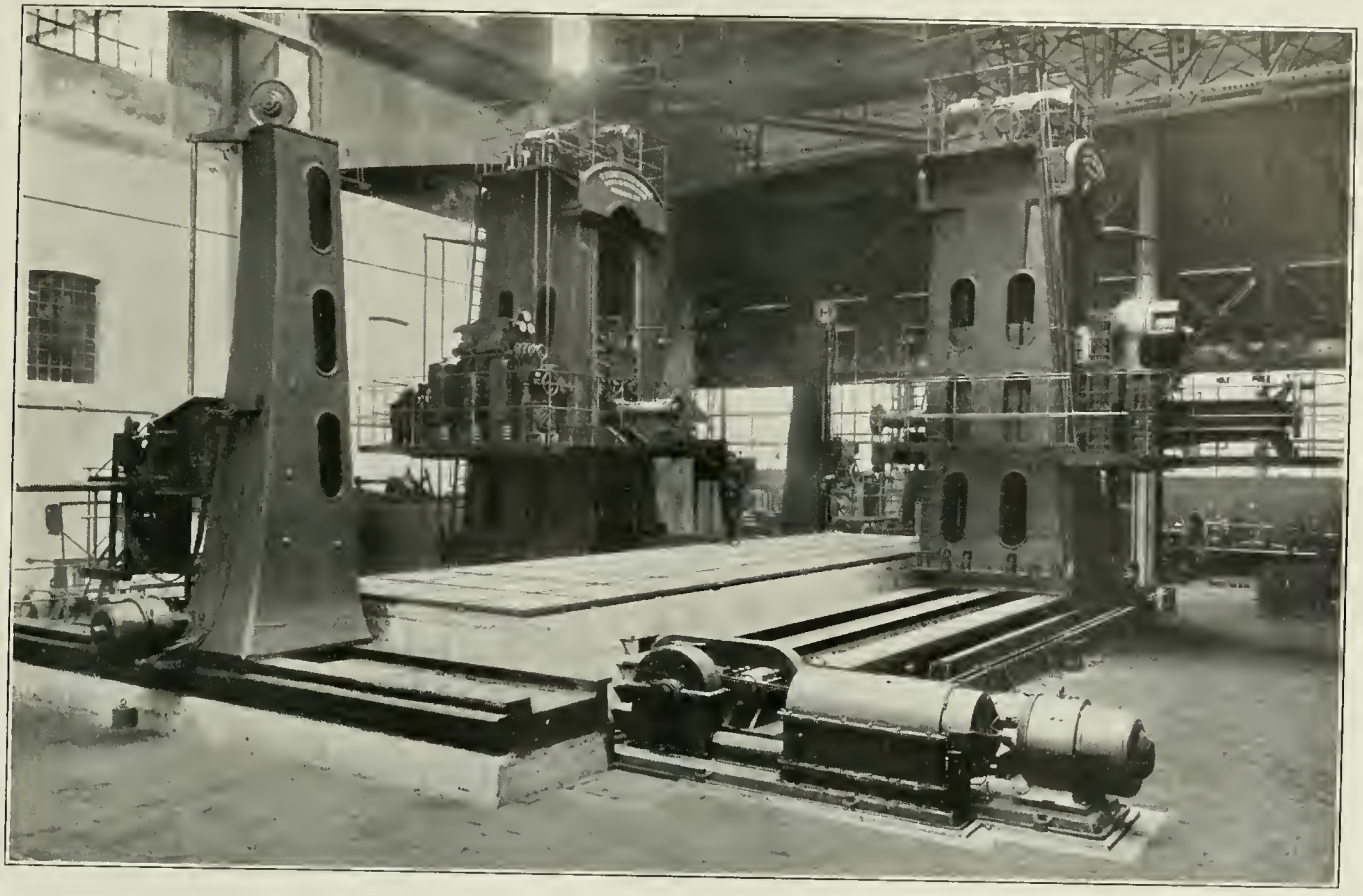
The method of determining the main scantlings has been somewhat modified from the present practice with a view to securing simplicity and directness of application. This provides for an increase of frame spacing in excess of the present practice of the Society, an increase which is considered to be justified by experience and to have the advantage of reducing the cost of construction. Further, a marked improvement has been effected in the tables giving the scantlings for the topsides, particularly as regards the permissible breadths of hatchways and their openings in the decks. Where the breadth of the deck openings differs from that stipulated, the thickness of the deck plating is to be increased or reduced subject to the provision of a minimum thickness.

In conclusion, it may be noted that, in the framing of the new rules, consultations have been held with representatives not only of British shipping interests, but with those of the National Committees of Lloyd's Register, which have been recently organised in America, France, Sweden, Holland and Japan, and thus the new rules, while leading to economy in weight and simplification of design, with consequent saving of labour, fully maintain the high standard which has always been set by the world's premier classification society.

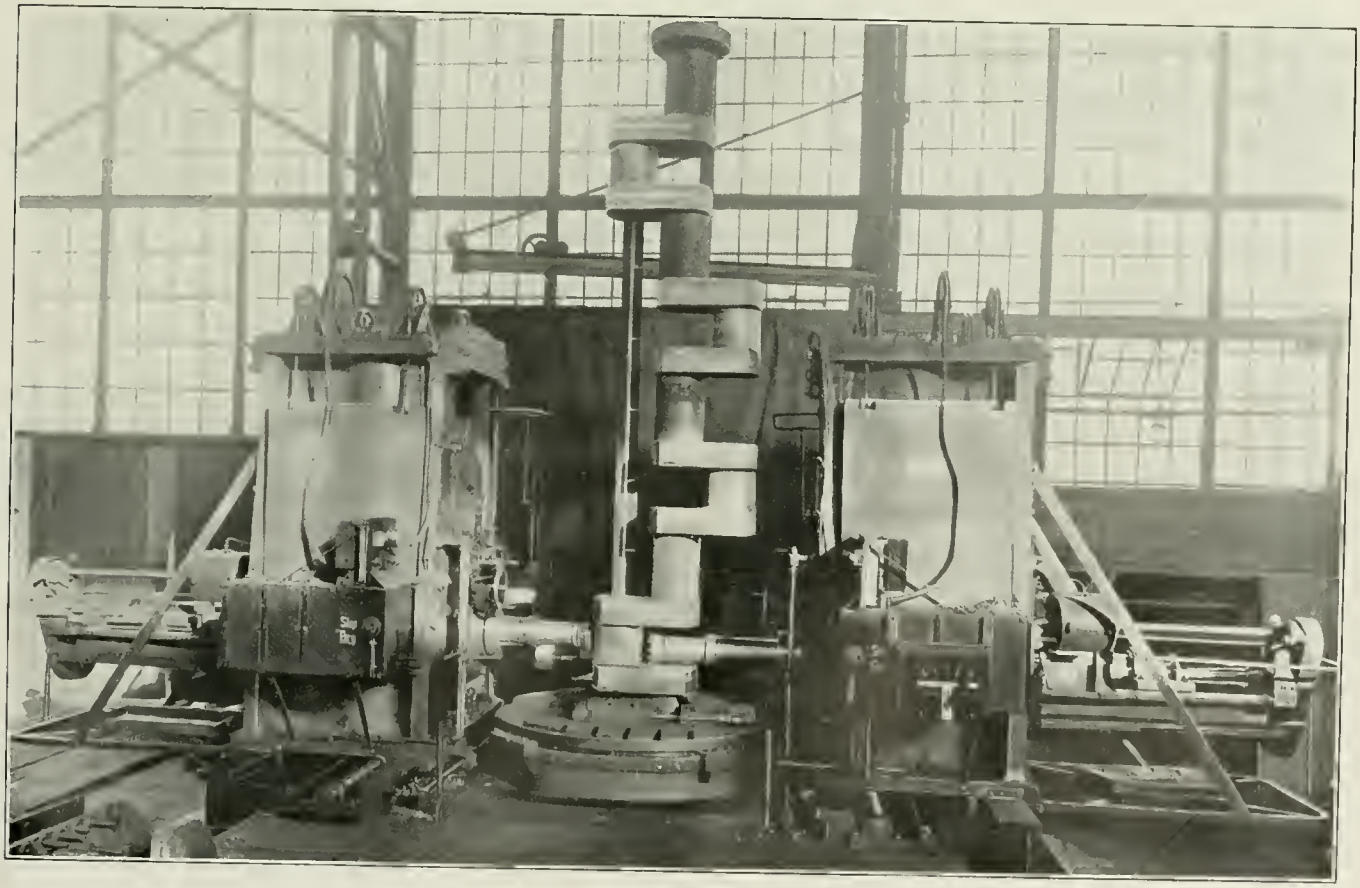


Burmeister & Wain's Main Erecting Shop at Copenhagen, showing several marine Diesel engines in process of construction. (*See page* 299.)

BURMEISTER & WAIN'S COPENHAGEN ENGINE SHOPS. (*See page 299.*)



Giant Boring and Milling Machine, weighing 500 tons.



Crank-Shaft Milling Machine provided with pit into which shaft descends.

[*Photo.*] [*Frank & Sons, S. Shields.*

Diesel-Electric Vessel "Tynemount," built in 1913 for Service on the Great Lakes. (*See page* 315.)

DEVELOPMENTS IN THE DESIGN OF MARINE OIL ENGINES.—IV.

Valve Operating Mechanism—Material and Design of Cams—Valve Setting Diagrams—Methods of Reversing.

The feature in the Diesel engine which seems to offer some difficulty to the sea-going engineer is the complication of the valve gear and mechanism as compared with the corresponding simple gear in the steam engine. The whole of the valves in the Diesel engine are cam operated, except in a few Continental engines, where eccentrics and roller paths are employed. The use of cams offers a very wide scope for the designer, and the wide differences in the methods of operation show clearly that the aim for perfection is not restricted to one channel, or even to orthodox engineering practice.

The cams are, with the exception of that for the fuel-injection valve, usually made of cast iron in one piece, with chilled profiles. Where lightness is an essential feature, wrought steel is used, and the section reduced as far as possible consistent with strength. In the case of the cast-iron cams, these are cast practically to finished sizes, only a grinding allowance being left for finishing to a master cam. The fuel-injection cam has a cast-iron body fitted with a separate adjustable toe-piece of wrought steel, as the permissible error in the opening of this valve is very small, and the construction followed allows of adjustment without re-keying. The air inlet, exhaust and air starting cams are as shown in Fig. 1, from which it will be seen that the profiles of the inlet and exhaust cams are tangential to the base circle. This design is suitable only for engines of moderately-slow speeds, and for high speeds the shape would require modification to maintain the same period of opening. It is essential that the air-starting cam should be made with a profile to give a very rapid opening of the valve, so that the engine may get away quickly to conserve the supply of starting air.

Two alternative methods of securing the toe-piece on the fuel-injection cam are illustrated in Fig. 2, the first showing the loose piece held by set screws, and the second by bolts through a flange on the toe-piece and the body. The gaps are carefully filled with packing pieces after final adjustments have been made on the bench trials.

Cam rollers are made of the same quality of chilled iron as the cams, or of wrought steel, ground in the bore and on the outside diameter. For reversing engines, the rollers are larger in diameter than are fitted in similar non-reversing engines, due to the necessity for the lever or push-rod end to clear the adjacent reverse cam.

The cams are carried on a camshaft supported in bearings of ample proportions and designed to prevent flexure during the operation of opening the valves against their springs, and in the case of the exhaust valve, against the gas pressure in the cylinder at the point of opening. The whole of the space between the bearings is taken up, particularly in four-cycle reversing engines, with the double or side-by-side cams, thus ensuring lineability of the cams and rollers. In non-reversing engines, where this is not the case, the cams are fixed in position by set screws or other suitable means.

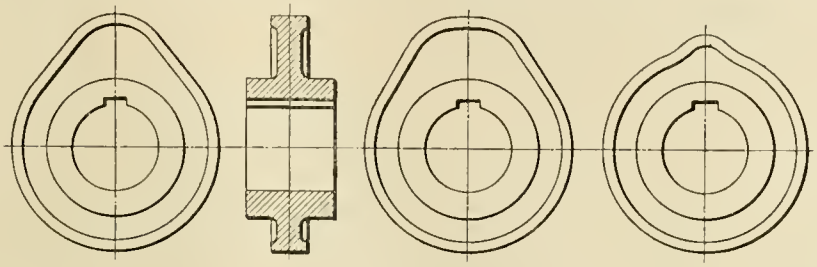


Fig. 1.

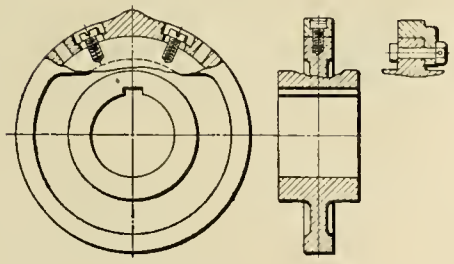


Fig. 2.

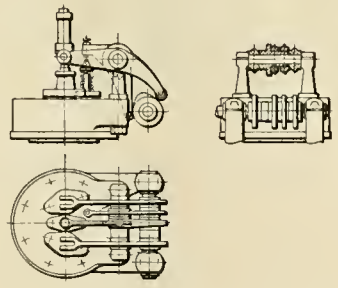


Fig. 3.

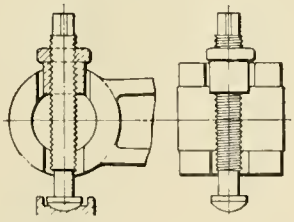


Fig. 4.

Details of Valve Operating Cams, Levers and Rollers.

A fulcrum shaft, supported from the cylinder covers, carries the valve levers. Fig. 3. is a typical arrangement where valve levers only are employed. At one end of the lever is mounted a roller which follows the contour of the cam, the other end engaging with the cam through suitable mechanism to obviate wear due to the path of the lever, a simple means being as shown in Fig. 4. The above description is applicable where the levers are directly operated by the cams, where the camshaft is in a lower position on the engine. The operation of the gear is as described above, with the exception that push-rods carrying the rollers in the lower end are fitted between the cams and the valve levers.

The camshaft in a four-stroke cycle engine is driven at half the engine speed, and in the two-stroke engine at the engine speed, the two usual methods employed being as indicated in Figs. 5 and 6, which are self-explanatory. A somewhat novel method is to drive a secondary cranked shaft from the engine crankshaft by spur wheels, long connecting rods coupling this secondary shaft to cranks on the camshaft.

Wide limits as regards openings of valves are permissible,

but it is necessary for the designed figures of an engine to be maintained in service if the best results are to be obtained, and makers usually, therefore, issue instructions in this direction, which it is desirable should be followed. The diagram shown in Fig. 7 is typical of the valve settings of a four-stroke cycle marine engine referred to the crankshaft, the same settings referred to the camshaft being as shown in Fig. 8. The air-inlet valve opens 20 deg. before the top centre and closes 20 deg. after the bottom centre. Compression takes place on the upward stroke and the fuel valve is opened about 4 deg. before the top centre, closing at about 35 deg. after the top centre. Expansion goes on until the exhaust valve opens 35 deg. before the bottom centre, and remains open until 10 deg. after the top centre, thus overlapping the inlet valve by 30 deg. The air-starting valve in a six-cylinder engine usually opens about 2 deg. after the top centre and closes 110 deg. after, but this period may be reduced in an eight-cylinder engine on acconnt of the smaller angle between the cranks. It will be understood that the period of opening of the valve can be varied by variation in the clearance between the roller and the cam, and it is therefore important when taking settings to ensure that these clearances are as designed, the usual figures being approximately ·02 in. for air-inlet and exhaust valves, and ·01 in. for the fuel valve.

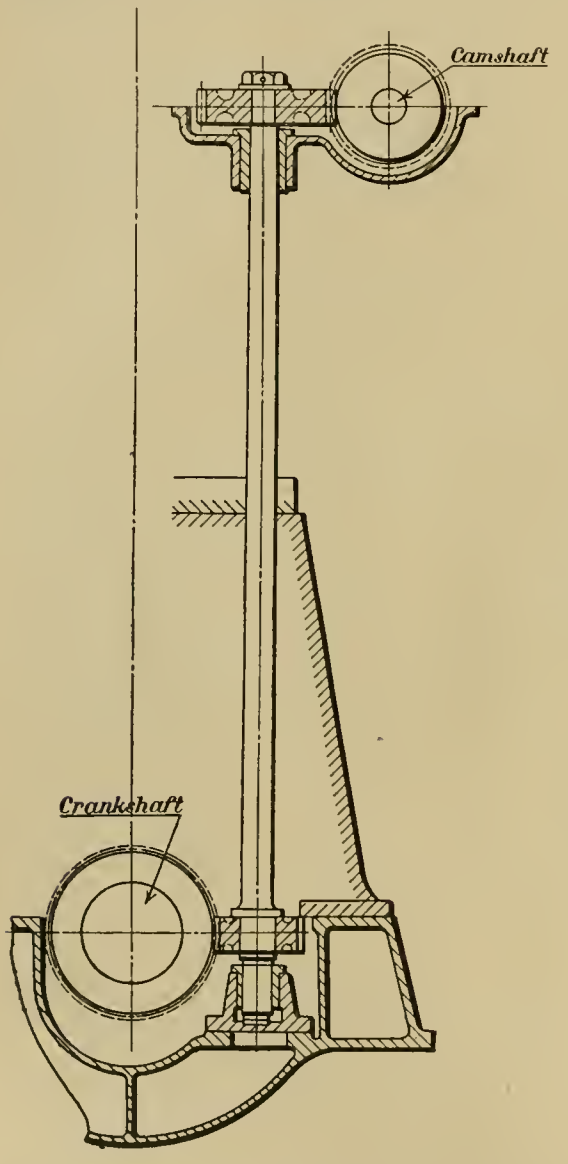


Fig. 5.

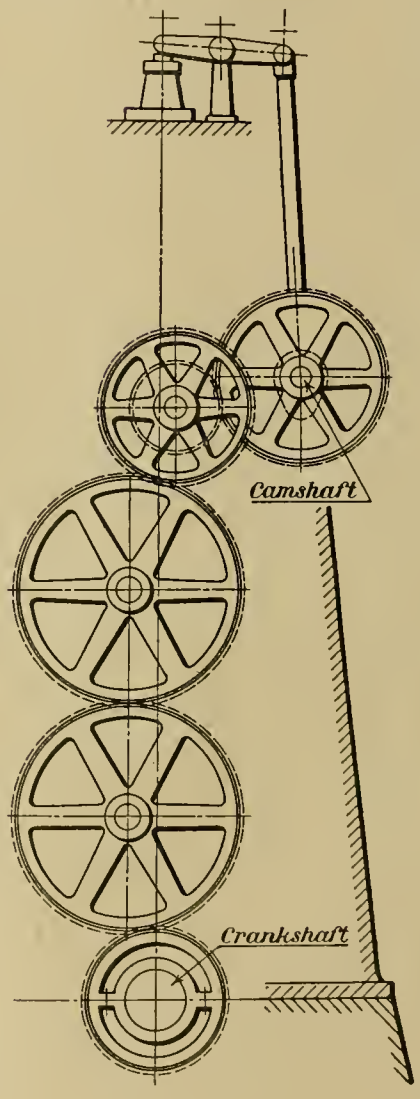


Fig. 6.

Arrangement of Cam Shaft Drive in Four-Stroke and Two-Stroke Engines respectively.

Fig. 9 shows a similar valve setting diagram for a two-stroke cycle, double-ported scavenge marine engine. The fuel-injection and air-starting valves are situated in the cylinder cover, the exhaust and scavenge being regulated by ports in the cylinder liner and the supercharging by a controlled piston valve.

Reversing Gears.

In the early days of the marine Diesel the reversing of the propeller shaft was arranged by the use of a reversible clutch, enabling the engine to keep running in the same direction for ahead or astern rotation of the propeller. While this arrangement is still followed in the case of very small-powered ships, the advent of larger units called for something further than this primitive arrangement, and in the modern Diesel ships the problem of direct reversing has been resolved to its simplest form involving no more trouble than when starting the engine, and with the various gears at present in use, it is readily admitted that orders from the bridge are responded to by the Diesel engine more rapidly than with the steam-turbine or reciprocating engines. The cycle for astern operation of the engine is identical with that for the ahead movement, and reference to Fig. 7 will clearly show that this cannot be accomplished by simply turning the camshaft in the reverse direction. An independent set of cams is therefore fitted for astern running, the ahead and astern cams for their respective valves being keyed adjacent to each other. In reversing, the engine is stopped and the rollers are engaged with the reverse set of cams before the engine is started up again. The methods for doing this are varied, three widely different types of gear being as shown in Figs. 10, 11 and 12.

In the case illustrated in Fig. 10, the camshaft is moved along to bring the required cams under the rollers. The power required to operate the reversing mechanism is derived either from a servo-motor or an electric-motor, the former being the more usual method. With the servo-motor, a rack is attached to an extension of the servo-motor piston rod which engages with a pinion on a cranked layshaft designed for a full turn of the pinion for the full travel of the rack. A slotted guide is fitted at the back of the rack engaging with a lever connected to the camshaft. Operation of the gear is effected in the following manner from the stop position: Air is admitted to the underside of the servo-motor, moving the piston and rack upwards for one-third of its stroke. In that time its layshaft has been turned and the cam rollers drawn clear of the cams; the lever on the camshaft, being in the straight portion of the guide, has not been moved. The slotted guide at the back of the rack is arranged vertically for the top and bottom portions of the travel of the servo-motor piston, the lever on the

camshaft being actuated only during the centre portion of the travel, during which period the rollers are held clear of the camshaft by the crank on the layshaft. The final upward movement of the servo-motor piston returns the rollers to the reverse cams.

A somewhat peculiar method of operation is illustrated in Fig. 11, the levers being pivotted eccentrically on a layshaft. The axis of the eccentric is not parallel with the layshaft and

Fig. 12 shows a diagrammatic arrangement of a distinctive type of reversing gear in which the camshaft is lowered from the valve push-rod rollers, and then slid along to the reverse position and raised to engage the reverse cams. The power for reversing in this case is also obtained by servo-motor through a layshaft on which are mounted eccentrics engaging with the camshaft bearings for raising and lowering the camshaft, and a scroll engaging, through suitable mechanism, with the cam-

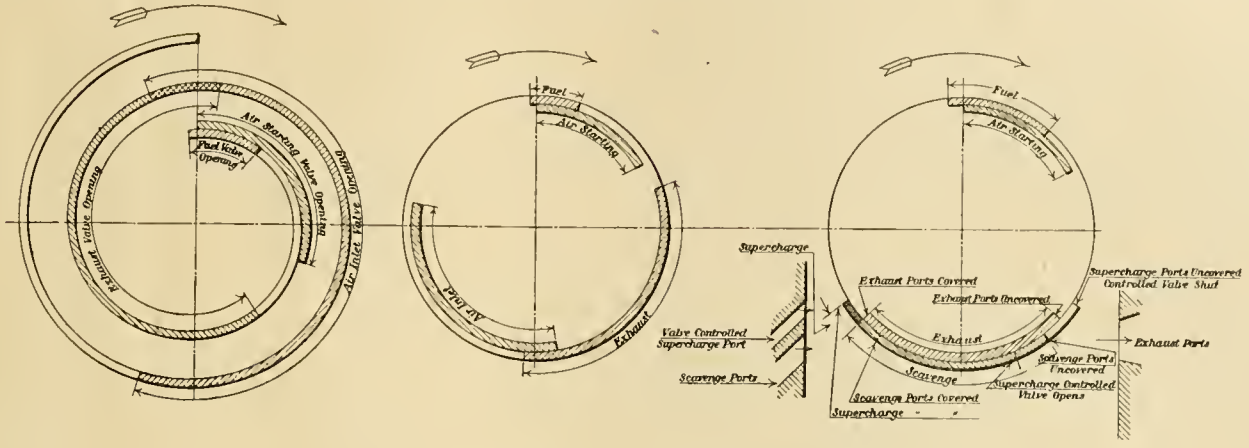


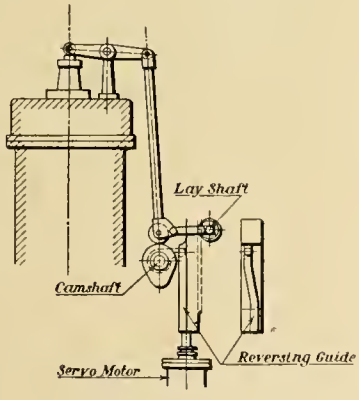
Fig. 7. Fig. 8. Fig. 9.

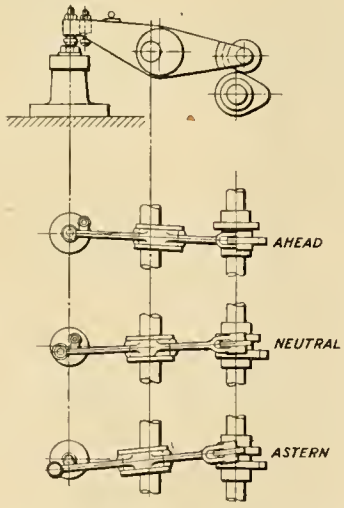
Typical Valve Setting Diagrams.

during a 180 deg. rotation of the shaft the rollers are raised from one set of cams and lowered on the reverse set.

A stop pin is fitted above the lever close to the valve tappet end to ensure that, in the case of valves being closed when the engine is stopped, the angular movement of the lever is taken at the roller end in order to clear the reverse cam. An auxiliary tappet of smaller size than the ahead tappet is provided for astern running. A somewhat detracting feature of this gear is that the axis of the roller in the astern position is not

shaft for sliding the latter. The scroll is designed to take effect generally in the same way as the slot in the gear shown in Fig. 10, the sliding of the camshaft taking place during the centre portion of the stroke of the servo-motor when the camshaft is clear of the cams, the first and last portions of the rotation of the layshaft being effective only so far as the engagement of the camshaft with the cams, by means of the eccentrics, is concerned. The camshaft bearings are hinged from strong brackets secured to the cylinders.





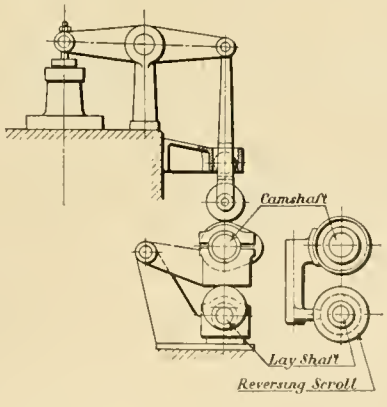


Fig. 10. Fig. 11. Fig. 12.

Alternative Types of Reversing Mechanism.

parallel with the axis of the cam, as will be seen by reference to the sketch, but as astern running of the engine is required for short periods only, this is perhaps not a very important factor. As against this, the push-rods, which are a feature in the design shown in Figures 10 and 12, are not required, the levers acting directly between the cams and the valves. The power for the operation of the gear is derived from a servo-motor with rack and a pinion on the layshaft, on the lines of that described in Fig. 10.

An alternative method of operation by moving the rollers themselves after the levers have been raised clear of the camshaft, is adopted in one type of engine, the rollers being carried in specially-designed wide jaws.

The reversal of a two-cycle engine is much simpler than that of a four-cycle engine, since the exhaust and scavenge usually take place through ports in the cylinder liner, and the only valves required to be reversed are those for fuel injection and air starting. This is simply effected by the rotation of the

camshaft through an angle of about 30 deg., which will also accommodate the reversing of the scavenge valves, when these are arranged in the cylinder head. This arrangement of valve settings, however, limits the scope for individual adjustments of the various valves to meet varying grades of fuel and conditions of running, and the best results cannot be maintained. The air-starting period, too, is not good, the valve opening very much before top centre, and losing considerable efficiency thereby. In view of these disadvantages, some two-stroke cycle engine makers have now adopted separate ahead and astern cams for fuel injection and air starting. Port-controlled scavenge is also being more widely adopted to obtain the advantages resulting from higher brake mean pressures and efficiency, with the result that the reversing gear has become more involved in design.

Fig. 13 shows diagrammatically the reversing mechanism for a Sulzer two-stroke cycle engine. The operation of the gear being effected by hand or power according to the size of the engine. In the sketch shown—after stopping the engine—a handwheel, or servo-motor in the case of the larger engines, rotates a layshaft a few degrees, removing, through levers and links, the ahead rollers from their cams and placing the reverse rollers in contact with the reverse cams. The handlevers, two of which are usually fitted, each controlling half the cylinders, are then pushed into the starting position, partially rotating the starting shaft and bringing into operation a cam which opens the air-starting valve in the cylinder head, at the same time, by means of eccentrics, putting into action the air-starting stop valve and preventing the fuel-valve lever from actuating the fuel valve. The engine is started up on air, and one of the handlevers is pulled down into the running position, turning the starting shaft and putting the fuel levers into operation and sumultaneously throwing the air-starting levers out of action, the cams turning at the same time close the air-starting valves. The other lever is pulled down, and the whole engine is running on oil. The arrangement adopted is such as to prevent the starting air and fuel valve being open to the cylinder at the same time, and obviates any risk of firing back into the starting flasks.

Manœuvring gear, consisting of mechanisms to control various functions of the engine, *e.g.*, the timing of admission and quantity of fuel, is an adjunct of practically every modern Diesel engine, and enables the best results to be obtained from the widely-varying conditions experienced in marine service.

Interlocks between various important functions of the engine are provided to obviate any risk of serious damage due to carelessness, the three principal being to prevent :—

(1) Reversing while the engine is starting on air or running on fuel.

(2) Air-starting valves being opened until the complete reversal of the gear is effected.

(3) Fuel being admitted when air-starting valve is open.

The whole of the control levers are, together with the principal gauges and master valves, grouped at the starting platform, which is usually situated on the floorplate level at the centre of the engine, the whole being arranged for convenient and easy operation by the engineer.

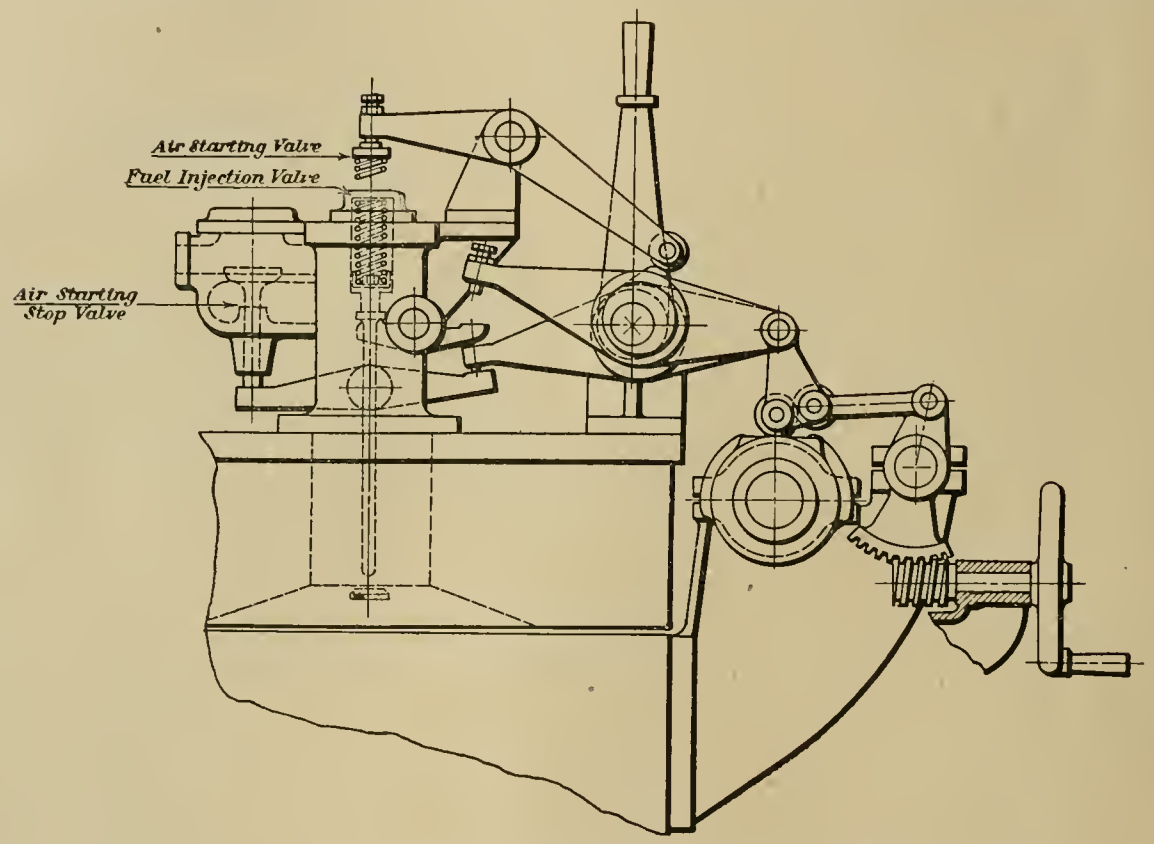


Fig. 13.

Diagram showing Reversing Mechanism for Sulzer Two-Stroke Engine.

The foregoing series of articles which might form the basis of a closer study of the Diesel engine, generally indicate the trend of the development of the modern Diesel engine, and some conception may be formed of the rapid advancement of this prime mover as compared with the early days of its development. Much remains to be done both in the designing office and the workshop before even the present ideal is reached, but makers are now in a position to offer definite guarantees of performances such as can be given with the average steam engine, so that the conservative shipowner need have little hesitation in considering the Diesel engine for new construction or for conversion. It is a significant fact that with mixed fleets of Diesel and steam ships, the latter are laid up in times of stress in preference to the former, a pointed factor of recognition of the superiority of the Diesel engine for commercial purposes.

SOME POINTS OF INTEREST IN CONNECTION WITH THE TESTING OF MATERIALS FOR SHIPBUILDING.*

By M. Léon Guillet, Professor of Metallurgy at the Conservatoire National des Arts et Métiers and at the École Centrale des Arts and Manufactures, Vice-President of the Société des Ingénieurs Civils de France.

The object of this paper is to draw the attention to a few points which are comparatively new regarding the methods of testing materials, more particularly materials employed in shipbuilding. This will be done very briefly and some reference will be made to earlier papers on the subject.

Tensile Test.

This test always forms the basis of specifications. While it is easy to measure the breaking strength, the elongation and the structure, it is sometimes very difficult to obtain the elastic limit with any degree of accuracy. Many methods of obviating this difficulty have been evolved, but in practice not one is entirely satisfactory, and the Commission Permanente de Standardisation (French Standards Committee), which has its offices at the Ministère du Commerce et de l'Industrie français, has had to be satisfied with the following method of verification : the test piece is subjected to the load specified as the elastic limit, and on releasing the load after a certain time no permanent set must have taken place.

The determination of the modulus of elasticity is a very delicate operation, and has to be carried out in a research laboratory. It is found from the results of all the tests which have been made that the modulus for steels is constant whatever treatment is applied, its value lying between 18,000 and 20,000. This coefficient is not very often determined in practice. To-day, when there is a very great variety of materials and a certain risk is often incurred in using them, this state of things cannot continue, and it would certainly be an advantage if the determination of the modulus were made less difficult. M. Guillery, who has already done much to simplify methods of testing, has just invented (see *Revue de Métallurgie*, February, 1922, "Mémoires," p. 101) an extremely ingenious device which enables the modulus of elasticity to be obtained without difficulty (Fig. 1).

"This method consists of a cylinder and piston, the rod of which is attached to one of the jaws. The pressure is produced either by hand or by means of a belt, by two special high efficiency pumps, one for quick action and the other for slow action with strong pressure. A reversing distributor enables the principal piston of the machine to be raised or lowered.

"On the bar are fixed, at a definite distance apart, two stops which can be rapidly fixed and removed, and the distance between them determines that part of the bar which is to be tested.

"The knife-edges of two branches of the amplifier, a double-jointed parallelogram suspended to the frame of the machine, rest on these stops. One of the two horizontal branches of this jointed parallelogram carries a water chamber one of the walls of which is formed by a metal plate with a rubber covering; in this way the chamber is made watertight, and at the same time a certain degree of movement is possible, with a consequent variation of volume in the chamber.

"It is evident that the parallel movement of the stops causes no variation of volume in the chamber, but the difference in the distance between the stops causes a displacement magnified three times at the opposite side of the jointed parallelogram.

"The chamber is under pressure, and is connected by a rubber tube to a glass tube, the section of which, as compared to the surface of the movable wall, is such that the level of water in the glass tube drops two thousand times more rapidly than the elongations which are produced. Thus the elongations are shown on a greatly magnified scale by the fall of the water level in the glass tube. The pressures shown by the gauge are exerted on a frictionless piston which rests on a calibrated spring, the deflections of which are proportional to the loads. These deflections are transmitted to the movable wall of a second water chamber of the same type as the first, by a system of levers separated by a roller, the displacements of which allow of the movement transmitted being reduced or increased, and at the same time kept proportional to the deflections. But the arrangement is such that the loads when increased cause the level of the water to rise in the tube. Thus the loads are represented on a scale chosen by the operator by a rise of water in the glass tube. The second water chamber has another movable wall regulated by hand so as to control the movement of the level of the water in the tube from a fixed reference point.

"It is therefore seen that, since by the displacement of the roller it is possible to cause a variation in the action of the loads, it is easy to find a position of the roller which will cause the loads to effect a rise in the level of the water equal to the distance it falls as a result of the elongations.

"Thus, if the modulus of elasticity is constant, a constant level during the period of elastic deformation is obtained, that is to say, the graphical representation of the test of the scale of the two movements in the tube will be, for this period, a straight line inclined at an angle of 45 deg. to the axes of the co-ordinates.

"The level will remain constant until the end of the proportional elongations, and its fall will be very easily observed, as the elongation is so greatly magnified. It is easy to see that the variable scale of the loads is an indication of the modulus of elasticity."

It is therefore sufficient to graduate one of the levers which transmit the stress ; a pointer fixed to the roller gives the value of the modulus of elasticity. The graduation is from 7,000 to 30,000.

Falling Weight Test.

Falling weight tests on notched bars have become very common as a result of the war. In France the Charpy and the Guillery testing machines are very generally employed. It is known that very important publications have been issued setting out the conditions to be fulfilled in order that the results may be comparable. The Commission Permanente de Standardisation has specified the following method of procedure :—

"It is not necessary that the type of testing apparatus should be fixed, provided that the principle of measurement and the accuracy of the graduations have been verified beforehand.

"The following conditions, however, should be fulfilled by the test :—

"The bar shall rest on bearers, 40 mm. apart, and shall be very accurately placed before the blow is applied. The bearers shall have their upper surfaces rounded to a radius of 1 mm. A clearance in accordance with that shown in Fig. 2 shall be allowed in order to reduce friction at the extremities and to avoid the wedging of the bar.

"The knife-edge fixed to the falling weight shall have a triangular section, the angle at the apex not being greater than 30 deg. The striking edge shall be rounded to a radius of 1 mm.

* Abstract of Paper read at the Paris Summer Meetings of the Institution of Naval Architects, July 5.

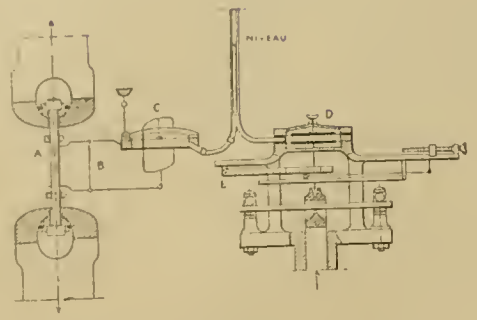


FIG. 1.—GUILLERY APPARATUS FOR ASCERTAINING THE ELASTIC LIMIT AND THE MODULUS OF ELASTICITY.

A. Test-piece. B. Double Articulated Parallelogram.
C. Water Chamber. D. Second Chamber.
E. Regulating Mechanism for Second Chamber.

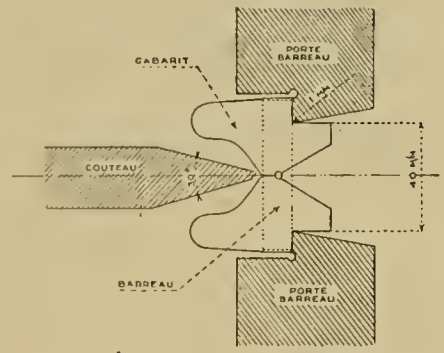


FIG. 2.—CONTROL OF SUPPORTS FOR SHOCK TESTS AND PLACING TEST-PIECE IN POSITION.

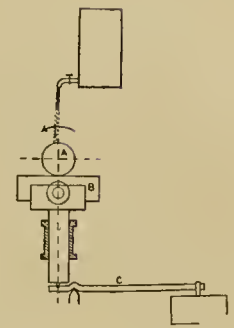


FIG. 4.—APPARATUS FOR WEARING TEST (JANNIN SYSTEM).

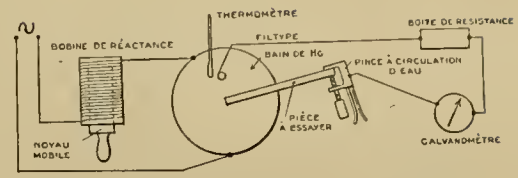


FIG. 5.—APPARATUS FOR THERMO-ELECTRIC TEST.

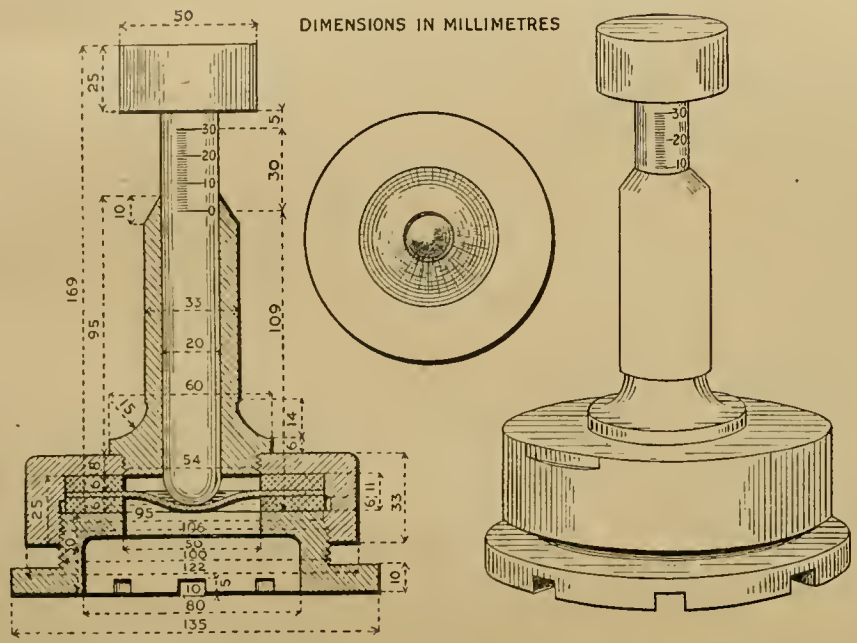


FIG. 3.—APPARATUS FOR PUNCHING TEST.

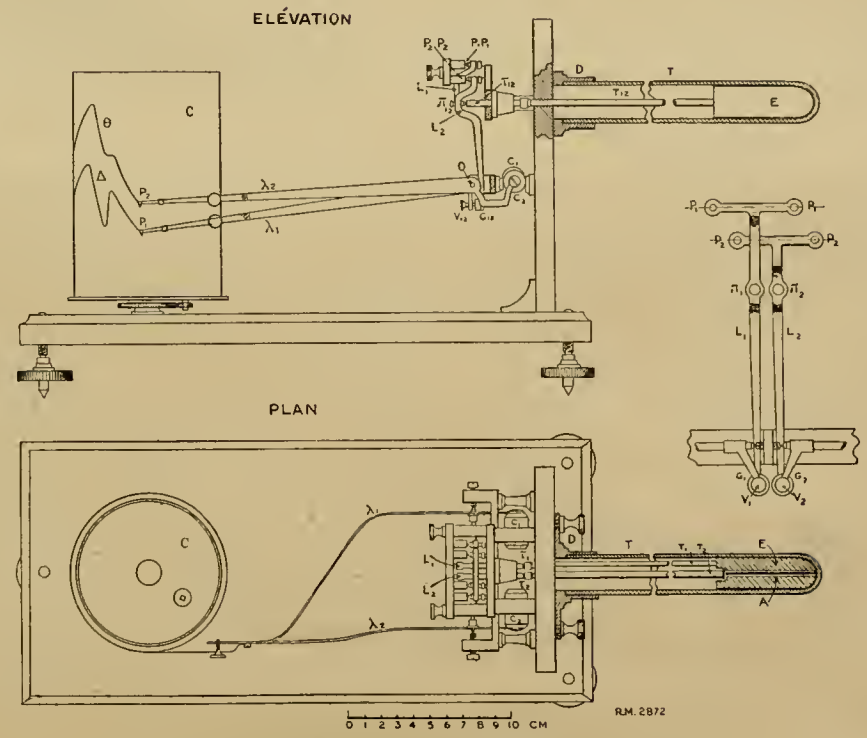


FIG. 6.—CHEVENARD SYSTEM OF THERMO ANALYSIS TEST.

Various Apparatus used for Testing of Materials. (*See page* 309.)

"It is absolutely necessary that the distance between the bearers shall be very frequently verified with a special template, and it is also necessary to ensure that the knife-edge fixed to the falling weight is exactly in the middle of this distance.

"The position of the bar on the bearers must also be very carefully verified for each test with a special template, the position of the notch being taken into account. The speed of the blow shall not be less than 5 m. per second.

"Unless any figure is specially prescribed for the temperature, it shall lie between 15° and 20° C. The influence of the temperature is much more marked than in any other method of testing."

Ball Hardness Test.

The ball hardness test is the only hardness test in current use; the sclerometer has not yet emerged from the region of research and the scleroscope has practically fallen into disuse in France. The employment of the ball hardness test has increased to an even greater degree than that of the falling weight test as a result of the exigencies of the war. All works where heat treatment is applied employ the test, and it is also used to obtain the breaking strength of *annealed material* (the formula does not apply for hard drawn or hardened materials). It is known that:—

$$R = C\Delta$$

R being the breaking strength; Δ the Brinell figure ($\Delta = \frac{P}{a}$-P, the pressure applied; a the area of the spherical cap in mm.²); C a constant for the same class of metals.

$$C = 0 \cdot 356 \text{ for steel.}$$

$$C = 0 \cdot 50 \text{ for brass.}$$

For ordinary cast iron the formula is a little less simple. It becomes:

$$R = 0 \cdot 2\,\Delta - 13.$$

In regard to this test the Commission Permanente de Standardisation has formulated certain regulations.

It is to be noted that M. Guillery has invented an apparatus which allows for rapid tests being made, the shortness of the duration of the test being compensated for by an increase in the load (*Revue de Métallurgie*, February, 1921, "Mémoires," p. 101).

Punching Test.

This test, which is of the greatest interest to manufacturers and users of sheet metal, has just been officially prescribed in the Specification for Sheet Aluminium.

As is well known, this test is as follows:—

A punch of definite shape and dimensions punches the metal and the depth of the deflection is measured at the instant the breaking of the plate takes place.

Fig. 3 reproduces one of the forms most frequently used and given in the official specification for sheet aluminium.

Wearing Tests.

We know that the results of wearing tests are very uncertain, and also that the tests are very delicate and sometimes of exceedingly long duration. The Martens, Derihon and Amsler machines are not in general use on account of one or other of these reasons.

A French engineer, M. Jannin, has constructed a very simple machine based on a new principle, which in a few minutes gives reliable results which can easily be expressed by a number (*Revue de Métallurgie*, February, 1922, "Mémoires," p. 109) (Fig. 4).

"Constructed for the purpose of determining the resistance to wear of the various metals used in the manufacture of journals and bearings, it allows of the determination of the influence of lubricating oil, of the polish of the journal, and of the hardness of the bearing upon the wear of these parts.

"The machine (Fig. 4) is composed of a horizontal spindle revolving at a uniform speed. On this spindle is mounted a journal, if a bearing metal is to be tested, or a roller A, if metal for the manufacture of shafts. Above the journal or roller a small vice fixes the tongue of metal B on which the wear is to be measured. This vice is mounted on the beam C of a steelyard, in such a way as to cause the metal tongue to exert a constant pressure on the journal. The journal is adequately oiled during the test by means of an oil reservoir placed above it.

"The duration of the tests is generally fixed at 5 minutes for the test on bearings and 15 minutes for the test on shafts. If it is desired to make a thorough study of the various influences affecting the wear, the test must last for an hour or two.

"The wear depends on the following five variable factors: the material of the journal, its hardness, its degree of polish, the material forming the metal tongue and the nature of the lubricant. It is evident that if four of these variable factors are maintained constant the influence of the fifth can be determined."

Alternative Tests.

These tests relate almost exclusively to the materials of moving parts. It is, however, desirable to call attention to the conclusions to be drawn from several definite results obtained with the well-known Cambridge machine in which repeated blows are directed on a test piece rotating about its axis.

Systematic tests carried out on different materials, ordinary and special steels, brass, aluminium bronzes, light alloys and especially materials and alloys of identical composition which have undergone different mechanical treatment, prove the great importance of the limit of elasticity from the point of view of resistance to these repeated light blows (Guillet, *Revue de Métallurgie*, February, 1921, "Mémoires," p. 96, and December, 1921, "Mémoires," p. 755).

Macrography.

Macrographic investigation is not yet generally used as a method of testing. This is a serious mistake. It ought to be very widely employed and be looked upon as a workshop method. It requires neither the very special apparatus of micrography, nor unusual care in the preparation of test pieces, nor even specialised knowledge for the interpretation of the results.

Physical Defects.

Hitherto physical tests have been regarded as delicate laboratory operations. We should like to call attention to two of these tests which may be very effective in certain cases M. Galibourg has recently shown (Reports of the Académie des Sciences, February 6, 1921) all the advantages which can be derived from thermo-electricity. Two steels may present practically the same degree of Brinell hardness although differing materially in composition, the one for example containing 0·3 per cent. C. and 3 per cent. Ni, the other 0·1 per cent. C. and 6 per cent. Ni. A thermo-electric investigation permits of these two steels being differentiated by comparison with a standard metal, a mercury bath, slightly heated, very rapidly ensuring contact between the material to be tested and the standard metal, and the current passing through a galvanometer (Fig. 5).

Chevenard has constructed a new dilatometer which is very strong and can be safely handled by anyone. By means of this dilatometer the points of transformation can be found, and it is thus possible to identify the different casts, at least for special steels (Fig. 6).

Conclusions.

This paper has been intentionally limited to an account of the most recent methods of testing, excluding those methods which come purely within the region of research work.

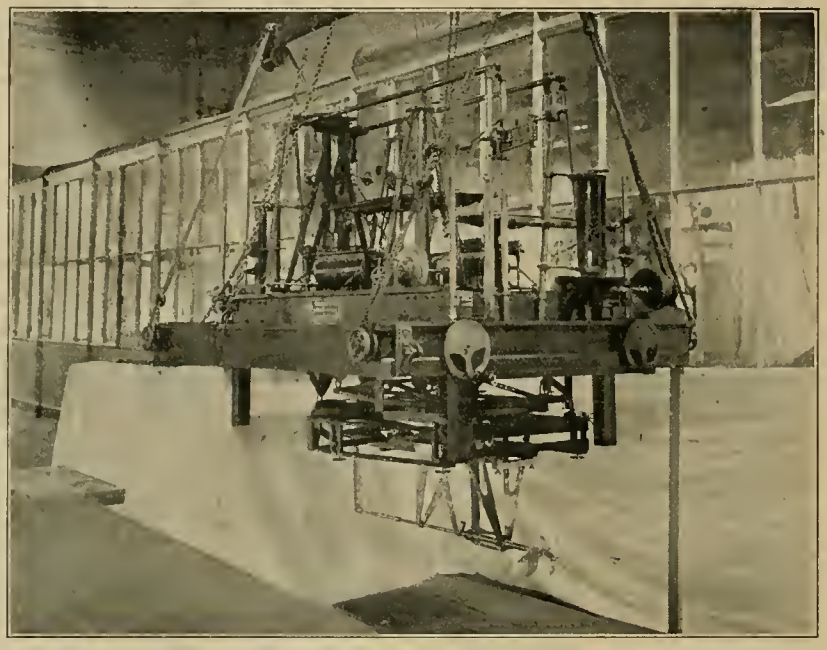
It will be seen that the user of metallurgical materials has within his grasp all that is necessary in order to obtain quick and accurate information regarding their value.

FURTHER EXPERIMENTS ON CONTRARY-TURNING CO-AXIAL SCREW PROPELLERS.*

By GENERAL G. ROTA, Royal Italian Navy.

Ship propulsion by means of double co-axial contrary-turning screw propellers has long been a matter of research. More than once results of experimental work have been presented before this Institution, and have given rise to interesting discussions.

In 1909 I had the honour of submitting the results of some experiments made in the Royal Dockyard of Castellamare di Stabia on a steam launch, whose single propeller had been replaced by two co-axial contrary-turning screw propellers. The same steam-engine which drove the single propeller was employed to drive by gears the double propellers. The experiments showed that practically the same speed was obtained in both systems, with the same indicated horse-power, so that the work lost in the gear transmission was evidently regained through a better efficiency in the propellers. I rated this gain to be about 20 per cent., but whatever be the real amount of this figure, one thing came out as stated, viz., that the total efficiency of double contrary-turning screw propellers was higher than that obtained by a single propeller. Still better results could be obtained, as compared with ordinary twin screws, if the gain due to the lesser resistance of the hull, and to the absence of brackets, shafts and bossings, had been taken into consideration.



Apparatus used at the Spezia Tank for Experiments with Model Contrary-Turning Co-Axial Screw Propellers.

Mr. Luke, in his interesting paper presented to this Institution in 1914†, brought a valuable contribution to this question, pointing out the value of hull efficiency elements under various conditions, viz., with a single screw, with twin-screw propellers on parallel axes, with double contrary-turning co-axial screw propellers (combination), with double co-axial similar-turning screw propellers (tandem), &c. Considering the arrangement of propellers in which I am now interested, viz., with contrary-turning co-axial propellers, the particulars of Mr. Luke's experiments pointed to the conclusion that if a real gain in hull efficiency was obtained in full-bodied ships, but less in fine-formed ships, on the other hand, the propulsive efficiency proper for the screw was far less than that obtained with the single screw or ordinary twin screws, in the ratio of about 86 per cent.; so that there was practically the same total propulsive efficiency with fine-formed ships, and superior only by 7 per cent. with the co-axial contrary-turning screw propellers associated with full-bodied ships as compared with the single screw. These results did not agree with the results I obtained from my first experiments, and this induced me to undertake new experimental researches into this question.

* Abstract of Paper read at the Paris Summer Meetings of the Institution of Naval Architects, July 6.

† "Further Experiments upon Wake and Thrust Deduction," Trans. I.N.A., vol. xli, page 33.

"Behind" Experiments (*i.e.*, Screw Revolving Behind the Model).

Screws in Action.	Propeller Efficiency, E	Full Model.				Fine Model.			
		Wake, $\frac{v-v_1}{v_1}$	Thrust Deduction, $1 - \frac{R}{S}$	Hull Efficiency, $e = \frac{v}{v_1} \cdot \frac{R}{S}$	Propulsive Efficiency, E. e	Wake.	Thrust Deduction.	Hull Efficiency.	Propulsive Efficiency.
Single	0·56	0·34	0·17	1·11	0·62	0·22	0.16	1·02	0·57
Double ordinary	0·56	0·20	0·15	1·02	0·57	0·13	0·13	0·98	0·55
Double contrary-turning co-axial	0·49	0·61	0·17	1·34	0·66	0·33	0·12	1·17	0·57

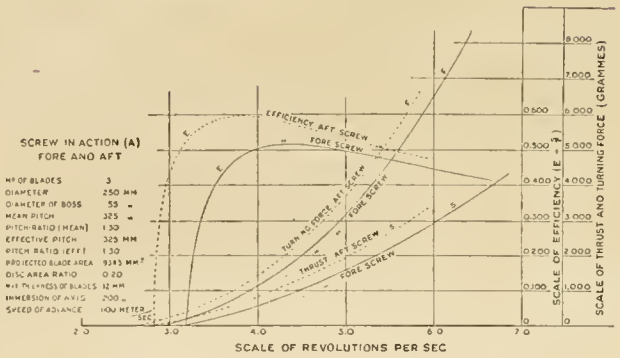


FIG. 1.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Co-axial, Contrary-turning { Fore Screw (A). / Aft Screw (A).

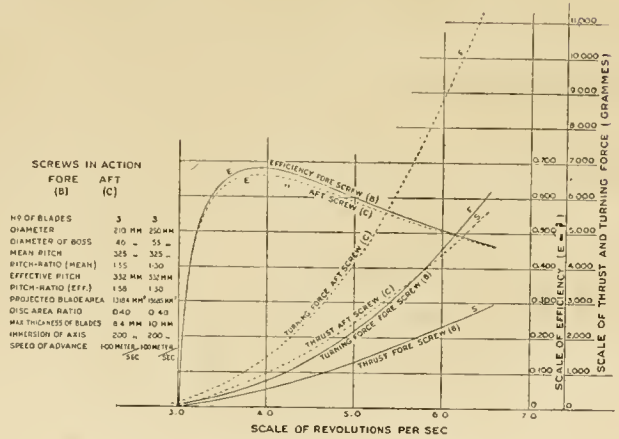

SCREWS IN ACTION
FORE (B) AFT (C)
EFFICIENCY FORE SCREW (B)
AFT SCREW (C)
THRUST AFT SCREW (C)
THRUST FORE SCREW (B)
SCALE OF REVOLUTIONS PER SEC
SCALE OF EFFICIENCY (E = P/D)
SCALE OF THRUST AND TURNING FORCE (GRAMMES)

FIG. 3.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Co-axial { Fore Screw (B) / Aft Screw (C) } Contrary-turning.

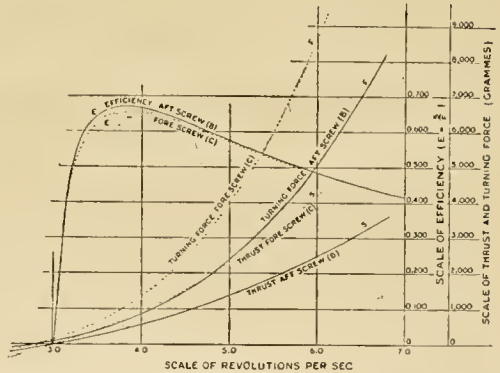

EFFICIENCY AFT SCREW (B)
FORE SCREW (C)
THRUST AFT SCREW (B)
SCALE OF REVOLUTIONS PER SEC
SCALE OF EFFICIENCY (E = P/D)
SCALE OF THRUST AND TURNING FORCE (GRAMMES)

FIG. 5.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Co-axial { Fore Screw (C) / Aft Screw (B) } Contrary-turning.

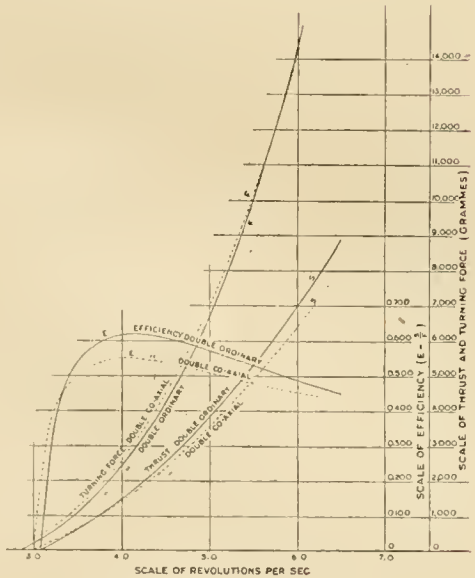

EFFICIENCY DOUBLE ORDINARY
DOUBLE CO-AXIAL
SCALE OF REVOLUTIONS PER SEC
SCALE OF EFFICIENCY (E = P/D)
SCALE OF THRUST AND TURNING FORCE (GRAMMES)

FIG. 2.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Double Ordinary Screw (A).
Double Contrary-turning Co-axial (A).

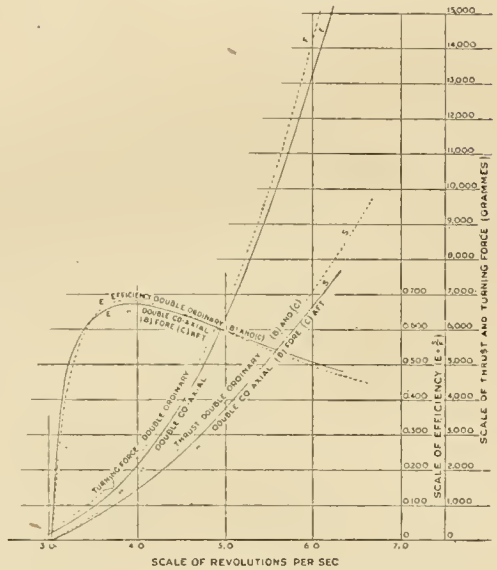

EFFICIENCY DOUBLE ORDINARY (B) AND (C)
DOUBLE CO-AXIAL (B) FORE (C) AFT
SCALE OF REVOLUTIONS PER SEC
SCALE OF EFFICIENCY (E = P/D)
SCALE OF THRUST AND TURNING FORCE (GRAMMES)

FIG. 4.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Hypothetical Double Ordinary (B) and (C), Double Co-axial Screws (B) Fore and (C) Aft, Contrary-turning.

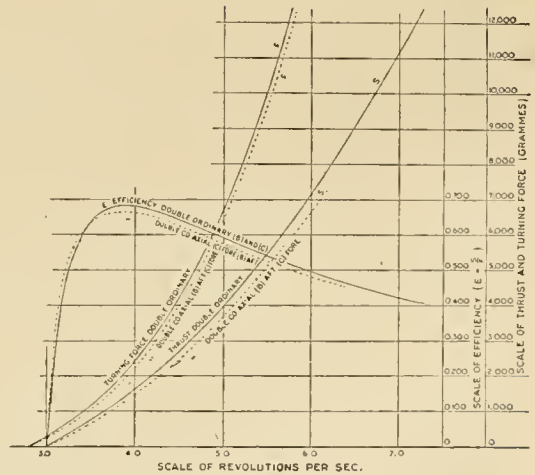

EFFICIENCY DOUBLE ORDINARY (B) AND (C)
DOUBLE CO-AXIAL (C) FORE (B) AFT
SCALE OF REVOLUTIONS PER SEC.
SCALE OF EFFICIENCY (E = P/D)
SCALE OF THRUST AND TURNING FORCE (GRAMMES)

FIG. 6.—CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
Hypothetical Double Ordinary (B) and (C).
Double Co-axial Contrary-turning { (C) Fore. / (B) Aft.

Results of Experiments with Contrary-Turning Co-Axial Screw Propellers carried out at the Spezia Experiment Tank.

Wishing to know exactly what are in every case the peculiarities of the efficiency of each of the two screws acting together while contrary-turning, we have succeeded in the experiment tank at Spezia in modifying the general arrangement of the apparatus for the experiments with model screws, so that we can now measure the thrust and turning force of each screw either separately or in combination. It is not possible here to give a description of that apparatus, but it is shown in the photograph reproduced on page 312.

The analysis of the performances of each screw enables us to investigate the influence of diameter, pitch-ratio, disc-area ratio and revolutions of the same, with the object of obtaining a higher efficiency, because, as is well known, this can only be attained by experiment.

In this paper, therefore, I give the results of some researches made with that apparatus, with the sole object of adding a small contribution towards the solution of model experiment problems.

Several sets of experiments were carried out with this apparatus, adopting different kinds of screws, and I shall describe the principal features of some of them. Symmetrical screws (type A) of 250 mm. diam., 325 mm. pitch, and a disc-area ratio of 20 per cent., have given results which almost agree with those given by Mr. Luke.

In Fig. 1 are given the thrust, turning force and efficiency curves as obtained with these co-axial screws. The difference between the two efficiency curves is considerable. The one corresponding to the fore propeller is much below the efficiency curve of the after propeller.

In Fig. 2 are given the thrust, turning force and efficiency curves resulting from experiments with the same propellers (A) fitted on parallel shafts as in the ordinary twin-screw arrangement; the same are compared with the thrust turning force and efficiency curves relating to contrary-turning screws on a common axis; the thrust and turning force being the sum of the same relating to the individual propeller; and the efficiency is the total efficiency of the propelling system. From this comparison it appears that co-axial screw-propeller efficiency for the model A is inferior to that of the single screw or the twin screws of same shape acting on parallel axes to an extent which agrees sufficiently with Mr. Luke's deductions; the efficiency of the double co-axial, for the case considered, being about 88 per cent. as compared with the same value for the ordinary twin-screw arrangement. With other combinations of screw propellers, however, the results were very different, so that it is possible not only to have a higher value of the ratio mentioned above, but also to have practically equal efficiency.

Diameter of Propellers.

Further experiments were made with other screw-propeller arrangements to investigate the influence of a less diameter for the fore propeller than for the after one and *vice versâ*, keeping a constant pitch and increasing the disc-area ratio as compared with the experiments previously mentioned. In a first combination (see Figs. 3 and 4), the fore propeller (B) had

diameter	...	= 210 mm.
pitch	...	= 325 mm.
disc-area ratio		= 0·40

and the aft propeller (C) had

diameter	...	= 250 mm.
pitch	...	= 325 mm.
disc-area ration		= 0·40

In a second combination the propellers were interchanged (see Figs. 5 and 6). The results were very interesting; the total efficiency of the co-axial screw propellers was practically the same in both combinations, and may also be considered to be the same as with equal open single or double ordinary screw propellers.

In view of the previous considerations, a good screw propeller efficiency can be obtained either with the two co-axial contrary-turning screws or with the single or ordinary twin screws; so that the total propulsive efficiency, which, as is well known, is the product of screw propeller efficiency multiplied by hull efficiency, for the double contrary-turning screw propellers will have all the beneficial influence of the high hull efficiency of the same combination compared with the corresponding figure for single and ordinary twin-screw arrangements, as was stated in the interesting communication made by Mr. Luke.

Mr. Luke's investigations showed, in fact, that with the double contrary-turning screw propellers on a common axis the hull efficiency was 1·34 to 1·17, according to the fineness of the hull, instead of 1·02 to 0·98 as in ordinary twin-screw arrangements, and in the same ratio in the whole will remain at least the corresponding value of total propulsive efficiency. I am inclined to think that by the use of double contrary-turning screw propellers, and with the arrangements which experience may suggest, one will obtain a great improvement in the total propulsive efficiency—not less than 20 per cent.—even without taking into account the gain which may easily be foreseen by reason of the reduced resistance of the hull itself as a consequence of the suppression of brackets, bossings, &c.

Propeller Guide Blades.

Other special devices to increase the ship-propulsion efficiency are already in use; the well-known fixed guide-blades used in Sir John Thornycroft's screw turbine propellers were shaped with a contrary curvature, as compared with revolving screw blades, so as to direct the water into a straight line aft and thus utilise the rotational component of the wake. Herr Wagner's counter-propeller is a similar contrivance designed to direct in a straight line aft the helicoidal motion of the wake.

The double contrary-turning co-axial screw propellers would give, in my opinion, still better results, considering the contribution offered to the whole thrust by fixed guide-blades or a fixed counter-propeller in a second propeller.

The arrangement of double co-axial contrary-turning screw propellers should therefore be considered with great attention by designers in cases where the difficulties connected with the arrangement of two co-axial shafts do not appear impossible of solution. Such a case is that of cargo-boats with very full hulls when the propelling machinery is far aft. There is also a possibility of utilising this system in submarines.

Machinery Arrangement.

It is not possible here to enter into details of the alternative machinery arrangements in mercantile cargo-boats, *i.e.*, whether steam turbines should be utilised to drive both shafts, or a combination arrangement with a reciprocating steam-engine on the inner shaft and a steam turbine on the outer shaft, or whether electric motors should be provided on both shafts.

The double contrary-turning co-axial screw-propellers would be, perhaps, suitable in submersible craft with the object of obtaining the simultaneous motion of both motors, electric and Diesel, for eventually increasing the speed on the surface. The advantages should be considerable; for example, a submersible with electric motors able to give a speed of 9 knots submerged and with Diesel motors, 12 knots surface speed. If it were possible to have all the motors acting at the same time, by adopting the co-axial contrary-turning screw-propeller system, the surface speed could probably be increased to 15 knots, and perhaps a little more.

Under ordinary circumstances only one screw is in action, the other revolves idle, and so increases the resistance as to require a higher thrust; but considering all aspects of the problem, it should be possible to ensure conditions such as to reduce and perhaps overcome the above difficulty.

Before concluding, I desire to express my gratitude to Captain A. Farina, of the Royal Italian Naval Construction Corps, for his valuable assistance in conducting the experimental work in the tank at Spezia, where he is now in charge.

THE PROGRESS OF ELECTRIC SHIP PROPULSION.

Early experiments with the "Electric Arc"—Diesel-Electric Propulsion on the "Tynemount"—Representative Turbo-Electric Vessels with and without Mechanical Reduction Gears—United Fruit Company's "San Benito."

In view of the very considerable interest being manifested in electric propulsion in this and in other countries at the present time, we propose to discuss briefly one or two examples of vessels which have been so equipped within approximately the last decade. It frequently occurs in the development of any machine or method of marine propulsion that in the early stages of its adoption only a limited measure of success is enjoyed. There are many among us to-day who, without the exercise of abnormal retrospective faculties, can recall the early tribulations of the motor-car, for instance. Each successive phase of marine propulsion has been subject to early and discouraging weaknesses which only the exercise of the most commendable perseverance and courage on the part of its pioneers and advocates, aided by the fruits of gradually accumulated experience, has overcome and secured to mankind the great benefits now enjoyed. The direct-driven turbine and possibly to a greater extent the double-reduction geared turbine as we know them to-day, have each been the record of sustained effort towards higher standards of reliability and efficiency, and these remarks may be similarly applied to the gradual development of the internal-combustion engine for marine purposes. In common with other systems, electric ship propulsion, which has to-day reached a comparatively high standard of reliability, was not conspicuously successful in its early stages, and but for the enterprise and tenacity of its early sponsors we should not find the system adopted in high-powered naval craft and enjoying the increasing confidence of the shipowner as it is.

"Electric Arc" Trials.

Among the staunchest advocates of the system was the late Mr. H. A. Mavor, of Glasgow. Mr. Mavor was untiring in his efforts to advance the cause of electric propulsion for ships, and numerous papers read and lectures delivered before scientific institutions and technical bodies are to his lasting credit. The scope of his work, however, was also of a practical nature, and under his direction Mavor & Coulson, of Glasgow, designed and equipped in 1911 an experimental vessel, the *Electric Arc*, with a view to demonstrating the possibilities of the system. This experimental vessel had a length of 50 ft., and was fitted with an oil engine of 45 b.h.p. The engine speed was approximately 800 r.p.m., and the propeller speed 400 r.p.m. During the trials, which were run on the Clyde, a speed of over 8 m.p.h. was attained, and the vessel revealed remarkable control in manœuvring: stopping, reversing and starting with great facility. One of the points demonstrated in the transmission gear was that while continuous current motors might be suitable for certain classes of work for limited powers, alternating current was regarded as being more suitable for the large powers associated with marine work. The results of these trials were considered to have furnished valuable data and excited considerable interest among engineers at that time.

Diesel-Electric "Tynemount."

The experience gained with the *Electric Arc* was soon to be applied in the case of a larger vessel, built by Swan, Hunter & Wigham Richardson, Wallsend-on-Tyne, in 1913. This vessel, the *Tynemount*, was built to the order of the Electric Marine Propulsion Company Limited, for service on the Great Lakes of North America. The dimensions of the vessel were as follows:—

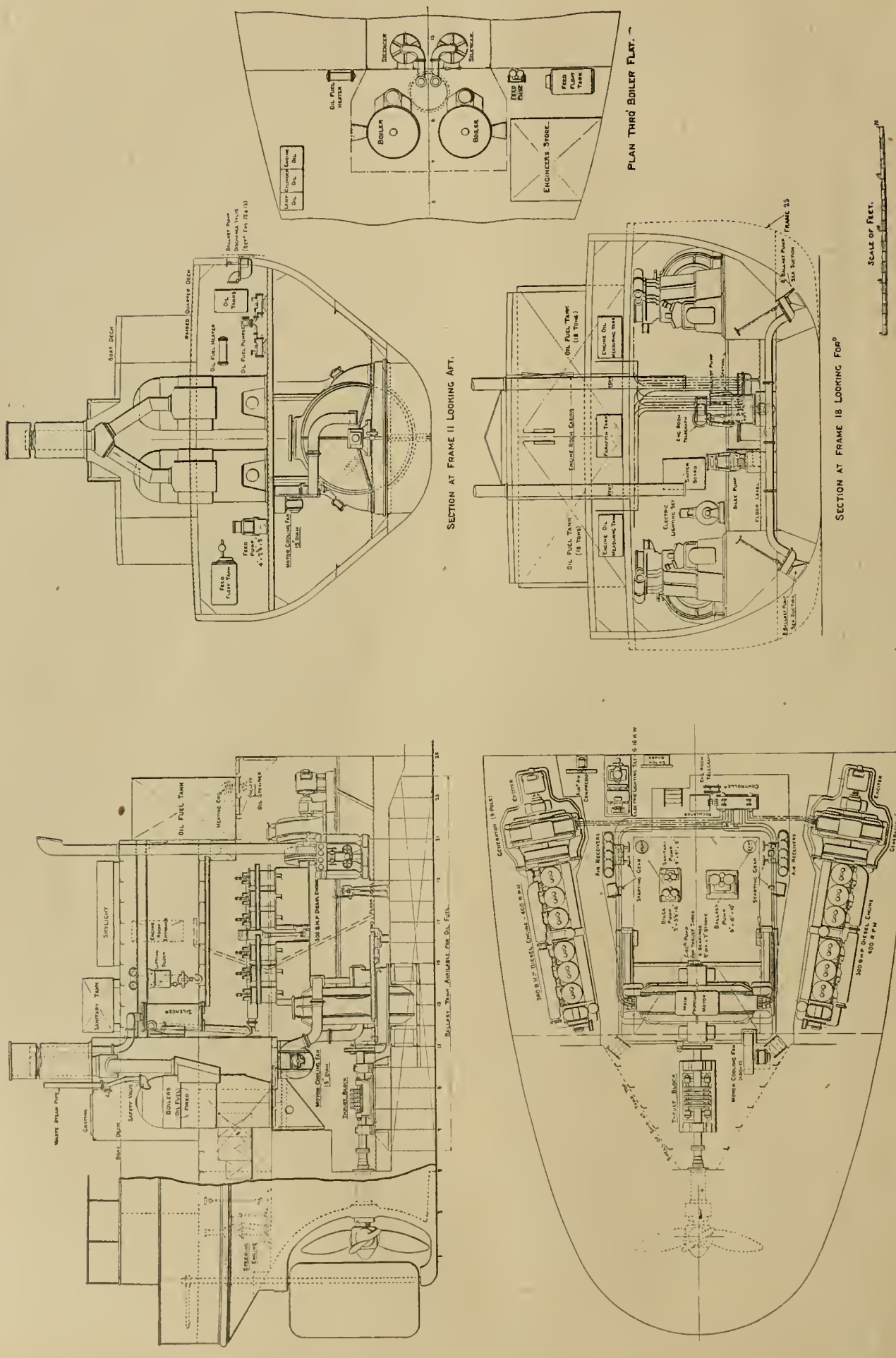
Length	250 ft.
Beam	42 ft. 6 in.
Depth moulded	19 ft.
Cargo Capacity	2,400 tons.

In arriving at suitable propelling machinery for this vessel, the somewhat exacting conditions of service imposed on the Great Lakes were given the fullest consideration. In Canadian canal work the power required varies between very wide limits. For a vessel of this size operating in the canals themselves, where a speed of 4 knots is the permitted limit, 150 i.h.p. or less is sufficient, although full speed is necessary in case of emergency. In the open lake in fair weather, 500 i.h.p. is sufficient to maintain fair speed, while 750 i.h.p. is at times necessary in contending with the St. Lawrence currents. The ease and flexibility of manœuvring possible with the electric system were considered to be particularly favourable for the nature of this service, which involved hundreds of rapidly alternating ahead and astern motions in negotiating such a series of locks as is encountered in the Welland Canal. The fact that no reversing was necessary in the case of the prime mover and that this agent, by the adoption of electricity, was removed from the immediate influence of propeller shock and the uneven loading and vibration incidental to a direct-propeller drive, led the designers to believe that these conditions were representative of work for which the Diesel engine was eminently suited and were such that the requirements of efficiency and reliability were likely to be fully met. When we recollect that it is now practically 10 years since the design of this vessel's original machinery was under contemplation, and that after a period of comparative inactivity in Diesel-electric propulsion it is only now, with a much more highly-developed Diesel engine available, that this combination gives promise of substantial adoption in mercantile tonnage, we are able to appreciate the advanced conception manifested in the design of the *Tynemount's* machinery.

Description of Machinery.

With the exception of the *Electric Arc*, previous applications of electric power to marine propulsion had employed continuous current, but Mr. Mavor's investigations had satisfied him that alternating current was more suitable for marine propulsion. The disadvantages attached to the use of alternating current in respect of regulations are associated with the greater number of conductors and particularly with the property of A.C. motors, that the speed of the motor bears a fixed ratio to the speed of the generator, and that any departure from this speed is associated normally with loss of efficiency and with more or less complicated devices for changing the frequency of the current alternations. In the *Tynemount* these difficulties were overcome by the use of more than one frequency applied to each individual motor. The currents of different frequency were carried in independent, mutually non-inductive circuits, the magnetic systems being entirely independent, but operating on a common rotor, so that their mechanical effects could be superimposed and the power transmitted in the separate circuits combined to produce the required mechanical effect.

The equipment on the *Tynemount* consisted of two three-phase generators driven by Diesel engines running at 400 r.p.m. The electrical output from each set was 235 kilovolt amp. at 500 volts alternating. The generators had six and eight poles respectively, giving frequencies of 20 and 26·6 per second. Direct-connected continuous-current machines, situated on the same shafts as the alternators, provided the exciting current, which was normally 30 amp. at 100 volts. A single three-phase motor developing 500 s.h.p. was coupled direct to the propeller shaft, which was of the ordinary type with marine thrust block. The rotor was of the simple squirrel cage type, without any electrical or mechanical connection



General Arrangement of Main and Auxiliary Machinery on Diesel-Electric Vessel "Tynemount." (*See page* 315.)

other than its rigid attachment to the propeller shaft. Two separate non-inductive windings for 30 and 40 poles respectively were incorporated in the stationary part of the motor. When each of these two windings was connected to the appropriate generator, the speed due to each was 78 r.p.m. By changing the connection on both windings the direction of rotation was reversed, and by connecting the 40-pole winding of the motor to the 6-pole generator the speed in either direction dropped to 58 r.p.m., or about three-quarters of full speed. If full speed were not required, one generator could be stopped and the other left running at full revolutions under governing control and at full economy, inasumch as the power necessary for three-quarters speed was about half that for full speed. If either generator were left attached to its own winding, and the other generator shut down, the ship was propelled by either engine at a little over half speed, the speed of the ship falling with the speed of rotation of the engine until an automatic adjustment of power and speed was reached at about half speed.

Control Gear on the "Tynemount."

The control gear consisted of an apparatus for changing the connections of the generator and motor windings respectively. There were five positions on the switch corresponding to the ordinary positions on the engine room telegraph. They were "Full speed ahead," "Half speed ahead," "Stop," "Half speed astern," and "Full speed astern." Each position of the controller was definitely fixed by means of cams and rollers, so that stopping at intermediate positions was avoided. The controlling gear provided for the interruption of the excitation of the generators while the switch was being moved from one stop to another, the exciting switch and the main switch being interlocked so that the switching-over operation was accomplished while the electric circuits were "dead." This arrangement avoided any injurious sparking. Provision was made by means of which, if desired, the control could be operated from the bridge of the vessel, and the engineer's attention confined to the lubrication and supplying of fuel to the engine to run at constant speed. By this method of control the stopping and starting of the Diesel engines for manœuvring was eliminated, and great economy in the use of compressed air was effected. The provision of twin prime movers was also regarded as a feature possessing certain advantages inasmuch as the interruption to the running of one set did not deprive the vessel of control. On page 324, we produce a photograph showing the *Tynemount* and the general arrangement plan of the vessel's original main and auxiliary machinery will be found on page 316. In view of the favour with which a substantial section of marine engineers regard the Diesel-electric combination for ship propulsion to-day, we have described the *Tynemount* installation somewhat fully. Unfortunately, the performance of the vessel's propelling machinery on service did not justify the high hopes which the early trials had seemed to warrant. Due regard, however, should be had to the fact that the Diesel engine of 10 years ago was not by any means the success that it is to-day.

U.S.S. "Jupiter."

In the later development of the electric drive, America has figured more prominently than any other country, and in the latter part of 1913 the *Jupiter* was completed at the Mare Island Navy Yard for service as a navy collier. The *Jupiter* is a vessel of approximately 20,000 tons displacement and there are two sister ships, the *Cyclops* and the *Neptune*. These three sister ships, being propelled respectively by one turbo-generator and two motors, two triple-expansion engines, and two turbines with reduction gearing, afforded a unique opportunity for observing comparative performances, and the results obtained by the electrically-propelled *Jupiter* may be said to have played a very great part in formulating the later policy of the United States Navy with regard to electric propulsion.

We give the main particulars of the three vessels in tabular form below :—

	Cyclops.	*Jupiter.*	*Neptune.*
Displacement	20,000 tons	20,000 tons	20,000 tons.
I.H.P. at 14 knots	5,600	—	—
Engine or turbine speed at 14 knots.	88 r.p.m.	2,000 r.p.m.	1,250 r.p.m.
Propeller r.p.m. at 14 knots	88	110	135
Weight of driving machinery	280 tons	156 tons	—
Character of driving machinery	2 triple expansion engines.	1 turbo-generator and 2 motors.	2 turbines, each with gearing.
Steam consumption in lbs. per s.h.p. hour	14 (estimated).	12 (tested)	—
Speed maintained on 48 hour trial.	14·6 knots	14·99 knots	13·9 knots.

It is not proposed to enter into a detailed description of the *Jupiter's* propelling machinery, and only the more outstanding features will be discussed. The vessel has twin-screws and the propelling machinery consists of a nine-stage Curtis turbine, driving a 5,500-kw. generator which furnishes current to an induction motor on each of the twin-propeller shafts. The machinery is all contained in one engine room, with the main turbo-generator mounted on its bedplate on the centre line of the ship. Both main motors are coupled direct to the propeller shafts. On her trials the *Jupiter* developed 7,150 s.h.p. and maintained a speed of 14·99 knots. The vessel has been in continuous service since 1913 and is claimed to have steamed a greater distance than any other collier in the same period. In the matter of manœuvring facility alongside ships, or in docks, the *Jupiter* is stated to be superior to either of her sister ships.

"Wulsty Castle" Machinery.

A further advance in the application of electric propulsion to the purely merchant vessel was made in the early part of May, 1918, when the *Wulsty Castle* ran trials on the North-East Coast. This vessel was built by John Blumer & Co., Sunderland, for the Lancashire Shipping Company, managed by J. Chambers & Co., Liverpool, under the supervision of William Esplen & Son, Liverpool. The vessel was of the three-island type, with poop-bridge and forecastle, and the machinery was accommodated amidships. Her principal dimensions were :—

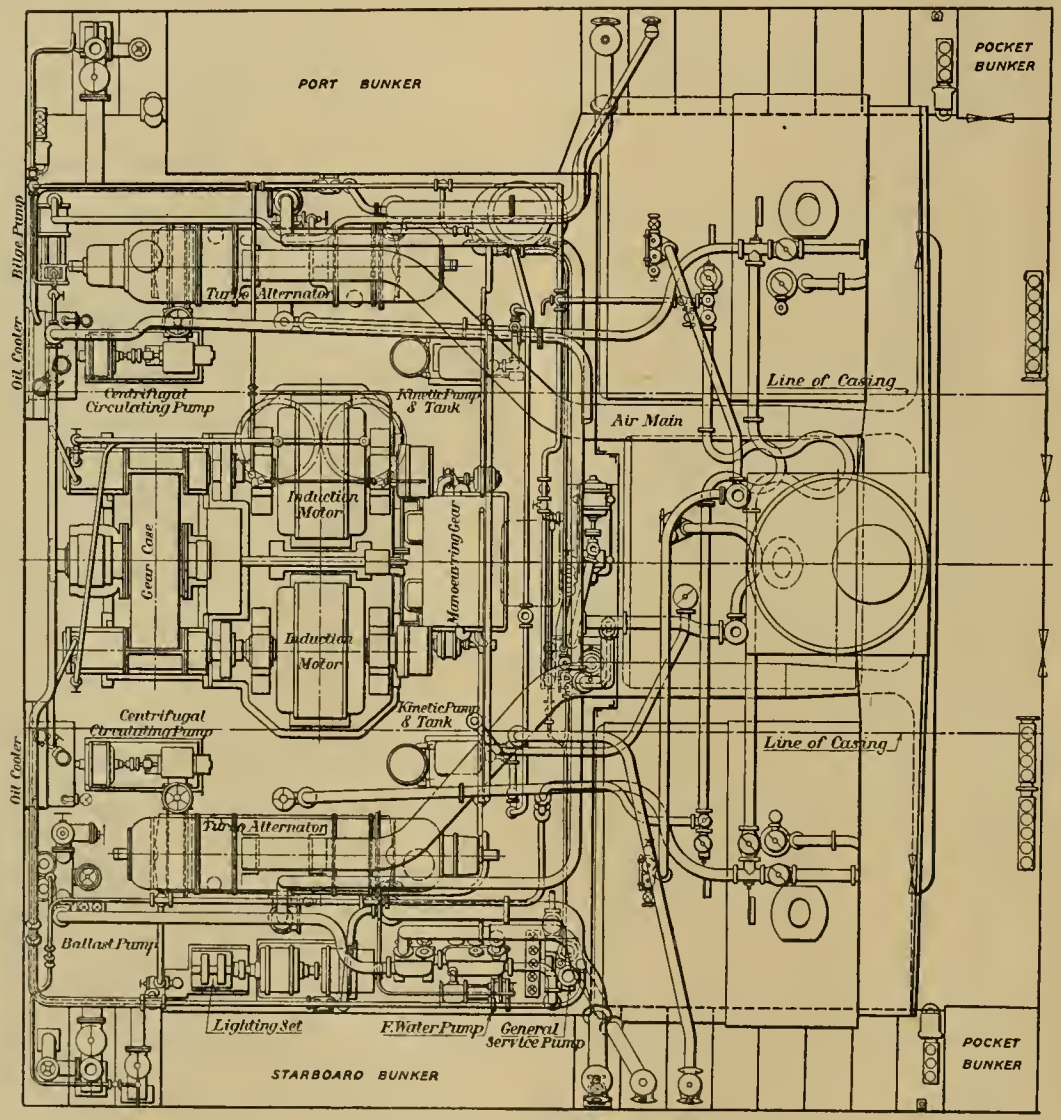
Length (B.P.)	356 ft. 3 in.
Breadth (extreme)	48 ft. 9 in.
Depth (moulded)	25 ft. 11 in.
Deadweight	about 6,000 tons.

On page 318 we show a plan illustrating the general arrangement of the machinery Steam is generated in two cylindrical boilers 13 ft. diam. by 11 ft. in length, and these work under Howden's system of forced draught, a special feature of which has regard to the ingenious method of supplying heated air to the furnaces. Fans are incorporated in the Ljungström turbo-alternators and air is drawn from the engine room, thereby ventilating the machinery spaces, passes through the alternators, cooling the windings, and thereafter in its heated state is introduced into the Howden forced-draught system. By this method the usual fans associated with Howden's system of forced draught are eliminated. Schmidt, Trafford Park smoke-tube superheaters are fitted and these are capable of superheating the steam to a total temperature of 625° Fahr. at the turbine stop valve. Two turbo-alternators, one on each side, are of the standard Ljungström type. Each set develops 625 kw. three-phase current at 650 volts 60 cycles per second at 3,600 r.p.m. The initial steam pressure is 180 lb. per sq. in.,

with 95 per cent. vacuum and a cooling water temperature of 70° Fahr. Two main induction motors are coupled to the single propeller shaft through double helical single-reduction gearing manufactured by the Power Plant Company. These motors together develop 1,500 s.h.p under service conditions and the propeller speed is about 76 r.p.m.

The stators are wound with single bars per slot and are insulated with seamless mica tubes, the end connections being of heavy copper strip. Cylindrical barrel windings have been adopted for the rotors and forced lubrication for the main bearings, which are of the pedestal type with split spherical bushes. An independent ventilating fan is provided in each

650 volts and at a speed of about 1,750 r.p.m. A three-phase electric motor drives each of two combination air pumps, one of which is of the kinetic type embodying the condensate and kinetic pumps in one casing. The speed of these pumps is about 1,470 r.p.m. The main boiler feed pump, which is of the turbine type and is capable of feeding both boilers at full power, is driven by a three-phase motor at about 3,540 r.p.m. Electric lighting is effected either by means of a motor drive or by a de Laval steam turbine. The combined set includes a D.C. 18 kw. generator which, with the three-phase motor and de Laval turbine, is mounted on a common shaft with disconnecting clutch gear. This set is capable of performing the dual



General Arrangement of Turbo-Electric Propelling Machinery on the "Wulsty Castle."

motor and these fans are mounted on the rotor spiders. The brush-lifting and short-circuiting gears are mounted on the forward end of the motor shafts and are operated by a handle which is interlocked with the starting hand-wheel. During the preliminary shop tests a full-load efficiency of 95 per cent. was obtained and the corresponding power factor was 0·875. The main motors, auxiliary motors, turbo-alternators, condensers and manœuvring gear were manufactured by the Brush Electrical Engineering Company, of Loughborough, to the specifications of the main contractors—the British Ljungström Marine Turbine Company.

The greater section of the auxiliary machinery on the *Wulsty Castle* is electrically driven. Two centrifugal circulating pumps are each driven by a three-phase 60-cycle motor at

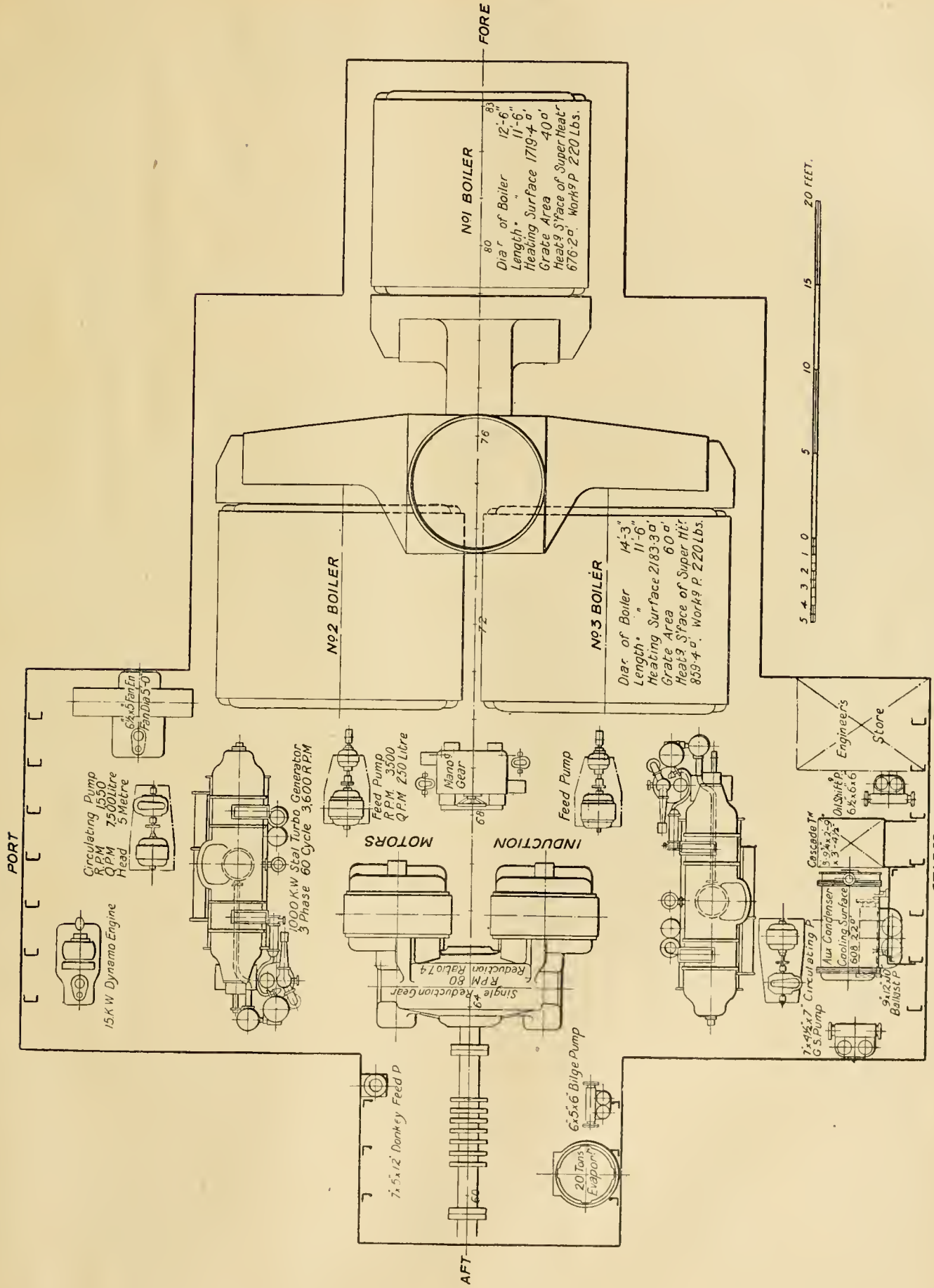
functions of supplying the electric lighting and wireless currents and of exciting the two propelling turbo-alternators.

Norwegian ss. "Modica."

In the latter part of 1920 the geared turbine, electrically-propelled steamer *Modica* left the yard of her builders, the Fredriksstad Mekaniske Verksted, Norway. This vessel was claimed to have been the largest ship built in Norway up to that time and her principal dimension were :—

Length (B.P.)	370 ft.
Breadth (extreme)	52 ft.
Depth (moulded)	28 ft. 6 in.
Deadweight	7,700 tons.

She was built to the order of Ivar An. Christensen A/S



Arrangement of Boilers and Machinery on the Japanese Electrically-propelled "Biyo Maru." (*See next page.*)

of Christiania and to the highest classification of the Norske Veritas. The main propelling machinery consists of two turbo-generators of the usual double-rotating Ljungström type, and these were manufactured by the Svenska Turbinfabriks Aktiebolaget Ljungström, Sweden. The combined total power developed is about 2,000 s.h.p. at 4,200 r.p.m. Each turbo-generator has a normal output of about 675 kw. two-phase current at 900 volts. Steam at 200 lb. per sq. in. initial pressure is supplied to the turbines, the revolutions of which can be varied 10 per cent. below and 15 per cent. above normal speed. Each turbo-generator is independently mounted on a surface condenser provided with rotary condensate and circulating pumps. Rotary feed pumps have also been adopted and these pumps are all electrically driven, the necessary power being derived from motors obtaining their current from the main turbo-generators. The energy of the steam turbo-generators is electrically transmitted to the propeller shaft by two asynchronous slip-ring motors driving through single-reduction gearing as in the case of the *Wulsty Castle.*

Japanese "Biyo Maru."

The first electrically-propelled merchant ship to be built in Japan was the *Biyo Maru* which ran trials early in 1921. This vessel was built by the Asano Shipbuilding Company, Tsurumi, Japan, to the order of the Toyo Kisen Kaisha, of Japan, and her principal dimensions are :—

Length (B.P.)	400 ft.
Breadth (moulded)	53 ft.
Depth (moulded)	32 ft.
Deadweight	8,800 tons.
Load draught	25 ft. 9 in.
Designed speed at sea	11 knots.

We produce on page 319 a drawing showing the general arrangement of the propelling machinery and boilers, and illustrations of sections of the propelling equipment are also shown. Steam is supplied by three single-ended Scotch boilers, two of these being 14 ft. 3 in. in diam. and 11 ft. 6 in. long, having three corrugated furnaces, and one 12 ft. 6 in. long, having two corrugated furnaces. The boilers are designed for a working pressure of 225 lb. per sq. in. gauge, and to burn either coal or oil alone, or coal and oil mixed. Howden's system of forced draught is adopted. For this purpose air trunks are led from the generators, the air used for cooling the generators being utilised for forced draught purposes.

The propelling machinery consists, essentially, of two sets of Ljungström turbines, each turbine driving two electric generators. The current from these generators is supplied to two induction motors which drive the propeller shaft through single-reduction gearing of the usual double helical tooth pattern. This machinery has all been manufactured by the Svenska Turbinfabriks Aktiebolaget Ljungström, at Finspong, Sweden, and its arrangement in the engine room is shown in the drawing reproduced on page 319, a photograph of the engine room being reproduced on page 321. The turbines, which are of the usual Ljungström type, are of the radial flow, double-rotation pattern, and are designed to work with steam at a pressure of 225 lb. per sq. in., superheated to 650° Fahr. at the inlet valve and exhausting into a vacuum of 29 in. Each turbine has two discs of blading turning in opposite directions, these being coupled to two three-phase, alternating current, self-exciting type generators having revolving fields.

Each generator is designed to be run at a speed of 3,600 r.p.m. and to give three-phase alternating current of 1,000 volts at 60 cycles per second. Each turbine, with its generators, is mounted on a surface condenser, which rests on a strong steel plate girder foundation. Each of the induction motors develops 1,360 h.p., the normal speed of rotation being 600 r.p.m.

The reduction gearing consists of a large double helical toothed wheel and two pinions, each of which is coupled to one of the induction motors. The ratio of reduction is about 7·5 to 1, so that the normal speed of rotation of the propeller shaft is 80 r.p.m., which corresponds to a speed of the ship about 11 knots when fully loaded.

The main manœuvring gear is a rectangular pillar stand containing switches, electrometers, and the liquid type resistances, and is worked with a large handwheel in the front.

The auxiliary machinery necessary for the working of the main machinery is all electrically driven, each unit being fitted with a separate induction motor taking current from main generators. It comprises two sets of air pumps, operating on the kinetic system, two circulating pumps of the centrifugal type, and two main feed pumps of the centrifugal type. The other auxiliary machinery in the engine and boiler rooms is steam driven.

The ship is lighted throughout by electricity, and for this purpose there is a motor generator set taking the current from the main generators. There is also a steam-driven generator for harbour use.

United Fruit Co.'s "San Benito."

A later application of electrical propulsion is to be found in the *San Benito* owned by the United Fruit Company, of Boston, U.S.A. This vessel took up service in the fruit carrying trade between the West Indies and America as recently as last year, and in this issue we describe and illustrate the principal features of her propelling machinery in some detail. The *San Benito* was built by Workman, Clark & Co. Limited, Belfast, and is the 34th vessel completed by that firm for the United Fruit Company. One of a class of four sister vessels, the *San Benito* differs from the other three in respect to propelling machinery only, inasmuch as these three are fitted with triple-expansion engines. Her principal dimensions are:

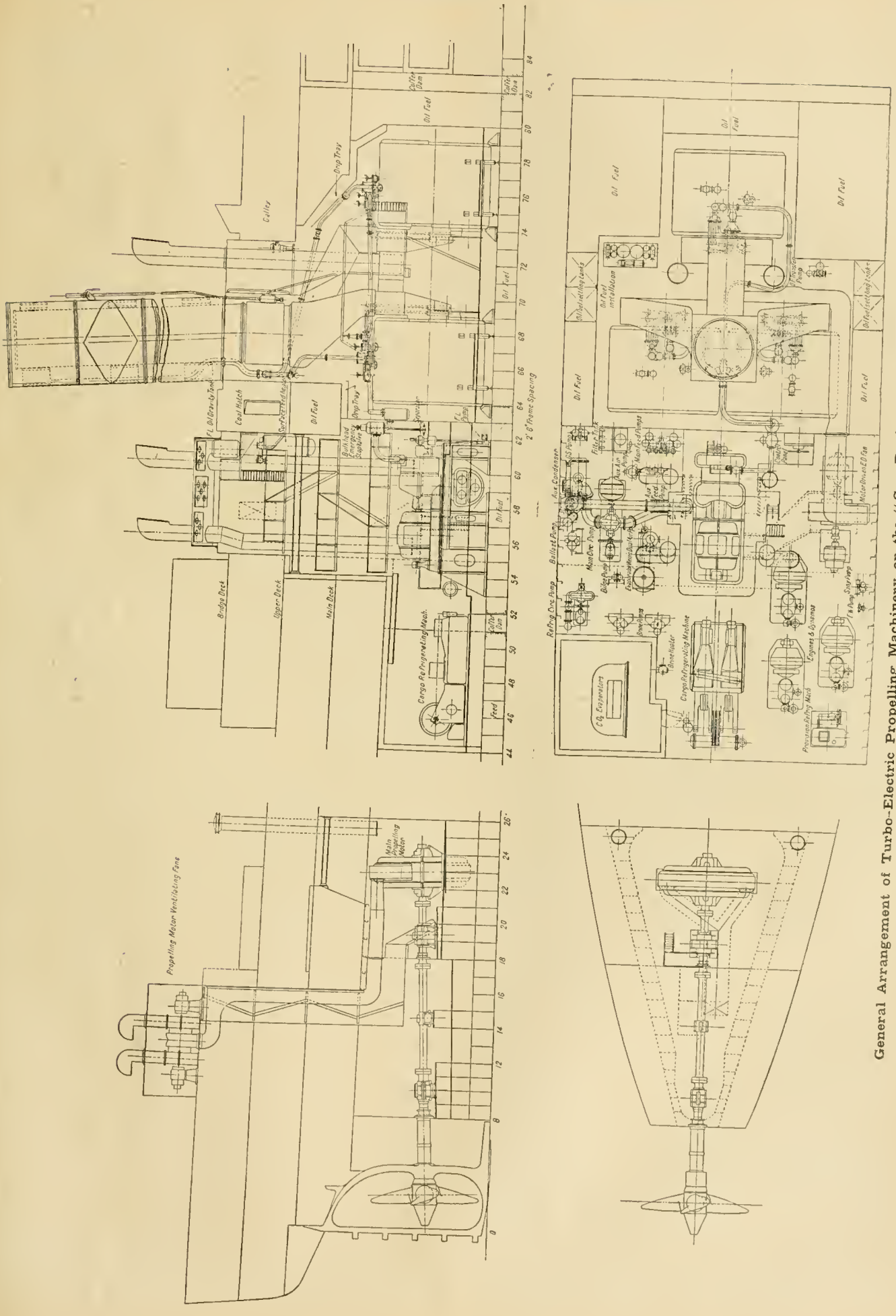
Length (B.P.)	325 ft.
Breadth (moulded)	46 ft.
Depth (moulded)	31 ft. 9 in.
Gross tonnage	3,724 tons.

From the general arrangement plan of the machinery reproduced on page 325, it will be seen that the *San Benito* differs in several respects from the vessels of the earlier types described in this article. In common with the U.S.S. *Jupiter*, the *San Benito's* main motor is connected directly to the propeller-shaft without the intermediate reduction gearing adopted in the majority of previous vessels. Unlike the *Jupiter*, however, her main motor is not an integral part of the engine room amidships, but is incorporated in a separate compartment aft. In order to make the comparison of the propelling machinery as complete as possible so that the owners would be in a position accurately to gauge the performance of the electric drive, the boilers of the *San Benito* are similar to those fitted in her sister vessels. Very ample boiler power is provided, due to the fact that, in addition to meeting the requirements of the large refrigerating plant, it is essential that a large margin be available so that schedule times may be adhered to in all weathers.

Arrangement of Propelling Machinery.

The general arrangement of the machinery illustrated on page 325 shows the three single-ended cylindrical boilers of 15 ft. 10½ in. internal diam. and 12 ft. 2 in. long, with four furnaces each and a combined heating surface of 8,532 sq. ft. These boilers are designed for a working pressure of 200 lb. per sq. in., and are arranged to burn oil fuel on the White system in conjunction with Howden's system of forced draught. The boilers of the *San Benito* differ only from those of her sister vessels in being equipped with an installation of Schmidt smoke-tube superheaters, supplied by the Marine & Locomotive Superheaters Limited, and capable of superheating the steam 200° Fahr. Parry tube blowers are also provided to clean the superheater elements.

(*Continued on page* 326.)



General Arrangement of Turbo-Electric Propelling Machinery on the "San Benito." (See page 320.)

The electrical propulsion equipment, designed to develop 2,500 s.h.p. at 100 r.p.m. propeller speed and to maintain a service speed of 12½ knots, was supplied by the British Thomson-Houston Company Limited, Rugby, who, by virtue of their association with the General Electric Company of America, have the benefit of the latter company's large experience in electrical equipment for ship propulsion. The single turbo-alternator is arranged in the engine-room amidship, while the propelling motor, which is directly coupled to the propeller shaft, is situated in a separate compartment right aft, together with the main water-cooled thrust block of the Michell type. With this arrangement the usual shaft tunnel is dispensed with and a cargo space free from all obstruction is obtained. The turbo-alternator, illustrated on page 328, is rated 2,040 kw. at 3,000 r.p.m., and comprises a 9-stage Curtis type turbine of the B.T.H. standard design, suitable for working with steam at 190 lb. per sq. in. gauge, superheated 200° Fahr. and driving directly a three-phase alternator which is designed to give a normal full load output of 2,040 kw., at 1,100 volts 50 cycles.

Main Turbine and Alternator.

The turbine is illustrated on page 327, and, from the sectional drawing, it will be seen that the first wheel is a compound velocity wheel, having two rows of buckets, and is followed by eight wheels, each with a single row of buckets. The supply of steam to the turbine is controlled by five hand-operated nozzle valves each controlling a group of nozzles, the number of valves opened or closed being such as to give the desired sea speed. This arrangement allows the main throttle to be set full open and full steam pressure maintained in the nozzle-chest under varying loads.

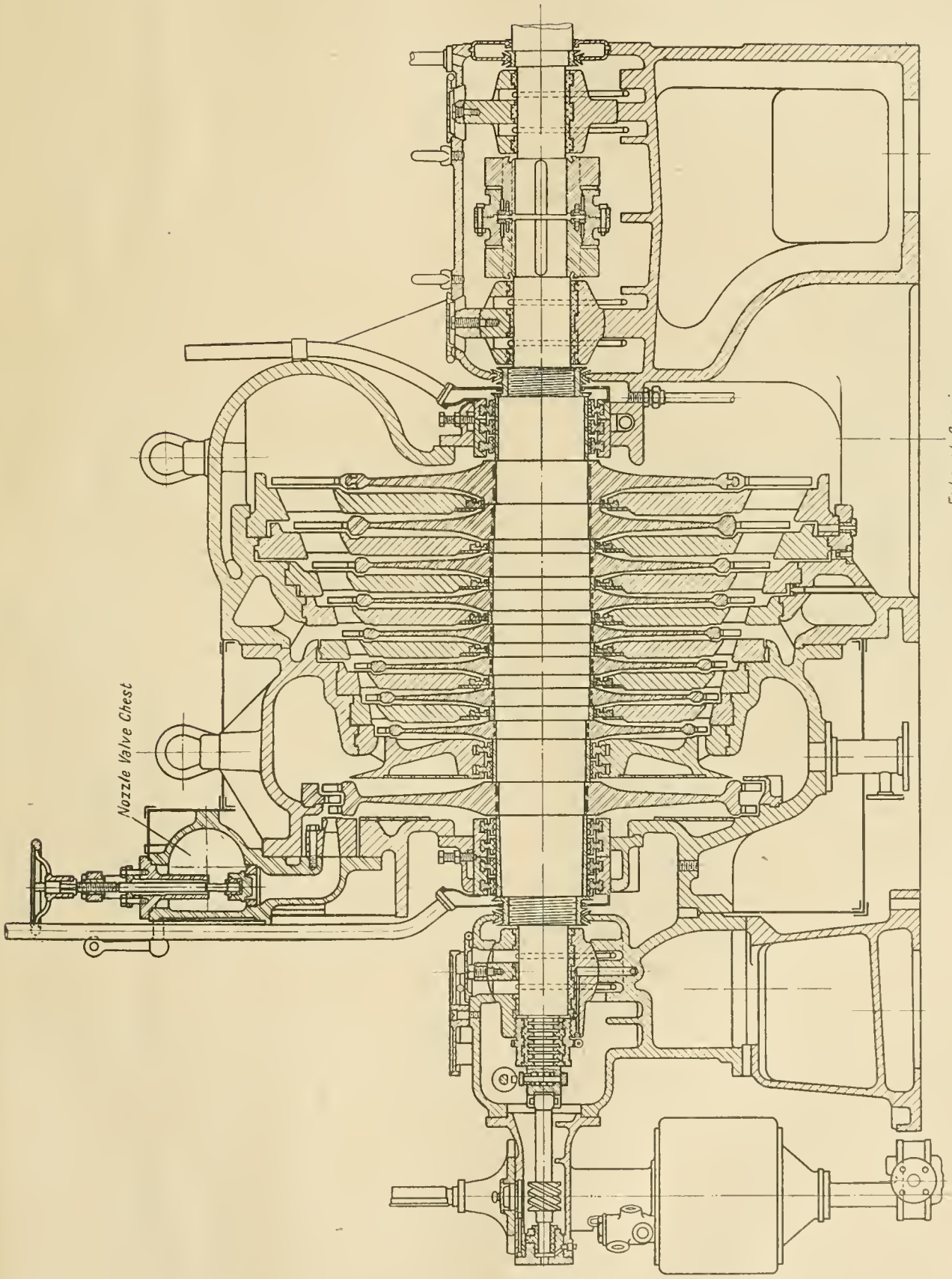
All exhaust steam from the auxiliaries which is not required for feed heating is admitted to the turbine through one of two inlets in the turbine casing; into the fifth stage when the turbine is working at full power or at any value down to 60 per cent. of full power; or into the first stage when the turbine is developing less than 60 per cent. of full power. An automatic shut-off valve, fitted in the auxiliary exhaust pipe line, and controlled by the steam pressure in the nozzle chest, cuts off the exhaust steam supply to the turbine whenever the turbine governor comes into operation and closes the main speed control valve during manœuvring periods. During these periods, a spring loaded valve diverts the auxiliary exhaust steam to the main condenser. Special governing gear is fitted to maintain any desired turbine speed between the limits of 3,200 r.p.m. and 300 r.p.m., irrespective of the load. For speeds down to 2,500 r.p.m. the control is maintained by a spring loaded governor, but, for speeds below this value and for the manœuvring periods, the turbine revolutions are controlled by an oil pressure governor, the setting of which is regulated by the movement of the main control handwheel. An emergency governor, of the out-of-balance ring type, is also fitted and closes the emergency stop valve when the turbine speed exceeds the normal speed of 3,000 r.p.m. by 15 per cent.

Two oil pumps, both of the gear type, are driven by a worm on the turbine shaft, one pump supplying oil for operating the manœuvring governor, and the second delivering lubricating oil to a gravity tank, at the top of the engine-room hatch, from which all the turbine bearings are supplied. A stand-by steam turbine-driven oil pump is fitted for starting purposes and emergencies, and is controlled by a pressure regulator in such a manner that, if the supply of lubricating oil should fail for any reason, this emergency pump would come into action. Duplicate oil coolers are provided, with the necessary valve connections, to enable either to be cleaned or repaired while the other is in operation, and the lubricating system is equipped with a de Laval motor-driven separator to purify the oil. This de Laval purifier, which has been supplied by Chadburn's Ship Telegraph Co., Liverpool, as sole licensees for Great Britain and Ireland, extracts by centrifugal force all forms of liquid and solid impurities, thereby ensuring that the lubricating oil is returned in its state of original purity. The main condenser is of the two-flow Uniflux type, and is arranged athwartships, under the turbine, being directly attached to the turbine exhaust branch. This condenser is designed to maintain a vacuum of 27½ in. with tropical sea temperatures.

The alternator is of the British Thomson-Houston standard type, self-ventilating, the air for ventilation being taken into the rotor at the bottom of the end shields and discharged through the stator core into a duct which leads into the inlet of the forced-draught fan. Temperature coils, which are fitted in the windings, enable the temperature of the machine to be read at any moment from a temperature indicator which is fitted on the control board. On page 324 we produce a photograph of the main propelling motor, which is a 60-pole, three-phase, end-shield type synchronous motor, designed to deliver 2,500 s.h.p. at 100 r.p.m. with current at 1,100 volts, 50 cycles. In the design of this motor, special reference has been made to the propeller characteristics, and also the design of both the alternator and motor has been made such as to ensure that the characteristics of these machines are in harmony. The rotor is provided with easily removable pole pieces which allow both the pole piece and the field spool to be removed together. A synchronous motor possesses certain advantages for marine work, in that it is possible to use a comparatively large air gap (¼ in.) and, at the same time, retain an efficient working machine. The characteristics and efficiency of this motor are shown in the form of curves on page 329.

The combination of alternator and synchronous motor constitutes an electrical speed reduction gear; in this case providing a 30 to 1 reduction between the prime mover and the propeller. Further, with this reduction, the prime mover always runs in one direction, eliminating the special turbine for astern running and all risks attendant to the application of highly superheated steam to this comparatively cold turbine. It also eliminates the losses due to the idle turbine wheels running in the reverse direction and, further, with electrical speed reduction gear, full power is always available for running astern. Temperature coils are fitted in the motor windings to enable the temperature to be read on an indicator which is located on the control board, and a separate D.C. motor-driven fan is provided for ventilating the propeller motor windings. The control gear consists of a contactor unit fitted with five main line and four field contactors, all operated in proper sequence by a cam shaft which is situated in the bottom of the unit. A keyed sprocket wheel which is keyed on the forward end of this camshaft is rotated by a roller chain which in turn is operated by a servo-motor fitted on the control board. The control panel, a photograph of which is shown on page 322, has fitted on it an indicating wattmeter calibrated in horse-power, an A.C. ammeter, an A.C. wattmeter, a D.C. ammeter for the motor field, a D.C. ammeter for the alternator field, two temperature indicators for the alternator and the motor, and a duplex electrical speed indicator which indicates the speed of both the motor and the turbine. The main control handwheel, also fitted on the control board, operates the contactors and controls the admission of steam to the turbine and rotates from the central or "stop" position through an angle of 165 deg. in a clockwise direction for full speed ahead, and in an exactly similar but opposite direction for full speed astern. This handwheel operates a servo-motor which gives prompt and positive operation of the contactors and makes it impossible for the operator to keep the contactors in a partially open position. In addition, the servo-motor is also set to ensure that the manœuvring oil governor is set to the minimum speed before any switching can take place.

Let it be assumed, for example, that the ship is going full ahead and it is required to go full astern. The handwheel is turned round in the direction indicated, and this action first sets the turbine governor in the minimum speed position, thereby closing down the steam. The field is then taken off both the motor and the generator, and, when the handwheel

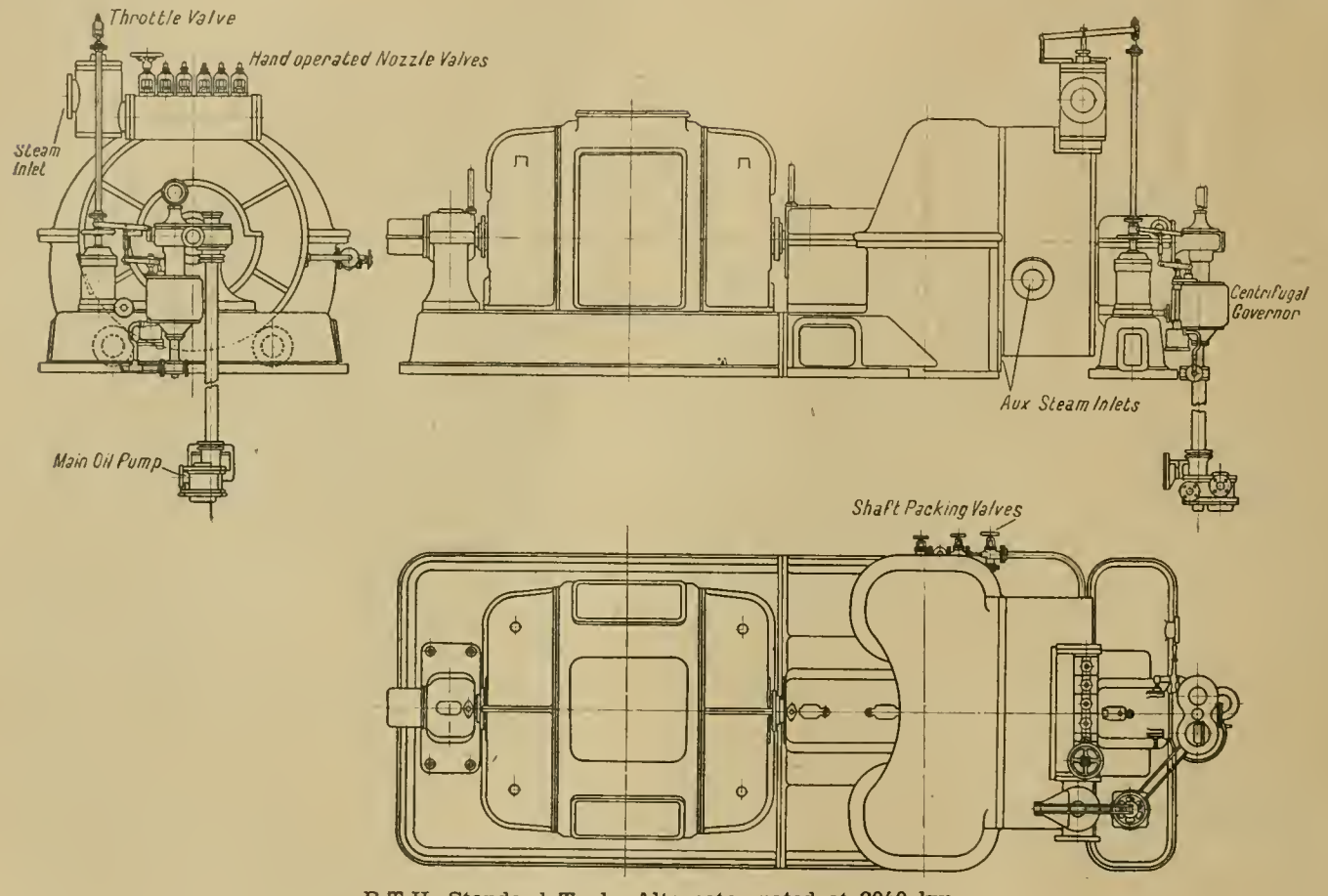


SS. "San Benito"—Main Turbine of the B.T.H.-Curtis, 9-Stage Type.

movement reaches the "stop" position, the three line contactors for ahead running are thrown out. On passing the "stop" position towards the astern running points, the three, line contactors for astern running are closed and this action is followed by the closing of the generator field contactors on the start point. At this point the exciter field is automatically strengthened, thus giving increased excitation to the turbo-generator while the motor is operating as an induction machine. As soon as the motor has accelerated sufficiently, as shown on the speed indicator, the handwheel is moved to the next point and the motor runs as a synchronous machine. Further movement of the handwheel opens up the steam from "dead slow" to "full speed astern" but the whole sequence described takes much less time to carry out than that which is required to follow the description.

An exception is found in the case of the 15 in. main centrifugal circulating pump supplied by W. H. Allen, Sons & Co. Limited, which is arranged to be normally driven by a 55 h.p. induction motor of B.T.H. make, operating with three-phase current derived from the main alternator at 1,100 volts. Alternatively, the pump may be driven by a compound engine supplied by the pump makers.

A Weir dual air pump replaces the engine-driven pump provided in the sister vessels. There are three D.C. generating sets, of 90 kw. capacity, but capable of withstanding a temporary load of 125 kw. The generators are supplied by the Sunderland Forge & Engineering Co., and are driven by compound enclosed forced lubrication engines of W. H. Allen's make. Two of these sets are normally in operation with the third as stand-by. One set takes up



B.T.H. Standard Turbo-Alternator rated at 2040 kw.

Interlocks are so arranged that it is impossible to operate in the wrong sequence, and, as will be seen from the foregoing description, the main line contactors cannot be operated unless the field is off the generator and the circuit is dead. During the whole range of the servo-motor movement from point 3 or "run point ahead," through the neutral point to a similar position astern, the steam control remains in the minimum speed or "dead slow" position. It will be noted that no large starting resistances are required with this synchronous motor and control system.

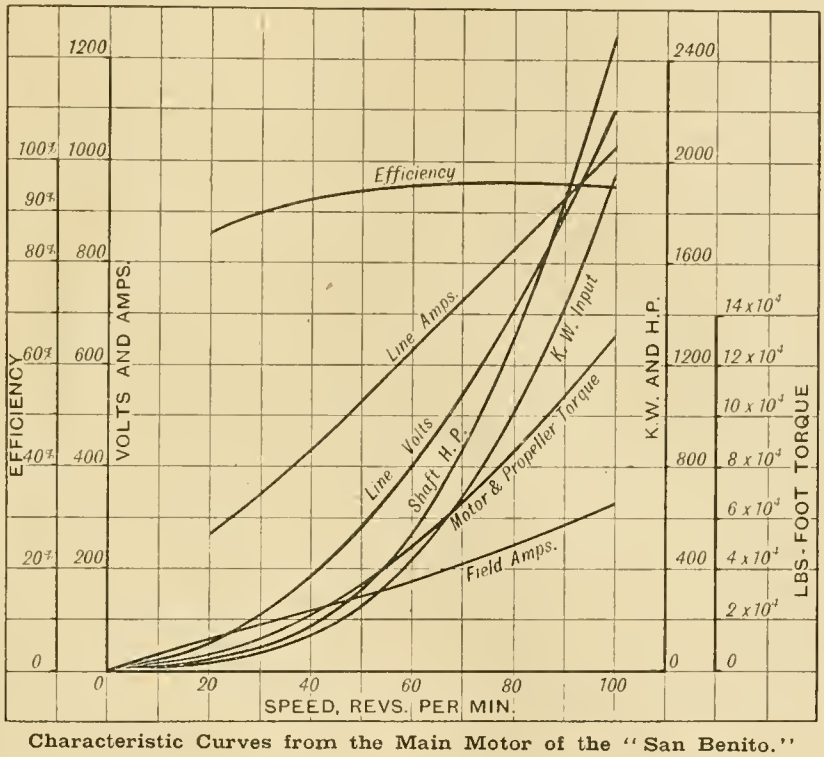
Auxiliary Machinery.

A very extensive equipment of auxiliary machinery is provided, and, in this connection, it was decided by the owners to duplicate, as far as possible, the auxiliaries fitted in the other ships of the class, and, incidentally, obtain an accurate comparison of the performance of the main propelling machinery. Thus, no attempt has been made to extend the application of electrical power for the driving of engine room and deck auxiliaries, beyond what is the owners' general practice, so that the usual steam-driven auxiliaries are largely retained. excitation duties, the second set generates at 110 volts for lighting and for the supply of power to the forced-draught fans, propelling motor, ventilating fans, and to the fans employed in connection with the cooling of the cargo spaces. These three 90 kw. sets compare with three 55 kw. sets installed in the sister vessels. With the above-mentioned exceptions, the auxiliary machinery is generally similar to that fitted in the rest of the class. A pair of Weir's feed pumps is provided, operating in conjunction with a Weir multi-flow surface feed heater, and controlled by a float working in a large gravitation filter and hotwell tank. The forced-draught fan is of Howden's make, and, following the owners' usual practice, is driven by a D.C. motor of generous rating supplied by the Sunderland Forge & Engineering Co. A second similar motor acts as stand-by in place of a steam engine, as provided in the sister vessels. The air discharged from the alternator windings is trunked to the fan inlets. The oil-fuel installation is supplied by the builders, being constructed under licence from the White Company. Pumps and heaters are fitted in duplicate, and the transfer of oil from double bottoms to settling tanks

is dealt with by a large Weir's pump designed for this duty. In connection with the oil fuel installation, arrangements are provided for the re-liquifying of oil which may have become congealed in double-bottom tanks and suction pipes. The system adopted is known as the "Rand" system, and is installed by Row & Davis, of New York. In place of the usual steam heating grids with their multitudinous joints and attendant disabilities the oil, in the first instance, is pumped from the settling tanks into special heaters of patented design and discharged to the tanks and suction pipes it is desired to bring into operation. The oil is discharged into the tank through a nozzle which revolves by reaction, so that the heating effect is distributed over a large area and, in a short time, oil may be drawn from the tank and circulation continued until a suitable temperature is reached.

Ballast duties are dealt with by a 9 in. × 10 in. × 10 in. Lamont duplex pump, while separate pumps of similar make are provided for general service, bilge, sanitary and fresh water services. A Weir 30-ton evaporator is fitted and is fed from the sanitary main and arranged for continuous brining. For duty in port, an auxiliary condenser of Uniflux design is provided in conjunction with a Weir monotype air pump, and a Weir auxiliary feed pump.

In connection with the cooling of the cargo spaces, a large CO_2 refrigerating set is provided, together with evaporators and two large brine pumps, while the refrigerating machine condenser is circulated by an engine-driven centrifugal pump made by W. H. Allen. In addition, a small set for provision refrigerating is fitted. Navigating and engine-room telegraphs, speed indicators and counters, voice pipes, &c., have been supplied by Chadburn's Ship Telegraph Co., of Liverpool.



Characteristic Curves from the Main Motor of the "San Benito."

Performance on Service.

The ship left Belfast for her trial trip and speed runs on the Clyde less than 24 hours after steam had been turned on to the turbine for the first time. The trials passed off very successfully and without the least hitch, a speed of 14·3 knots being reached, and two days after returning to Belfast she left for Valencia and other ports in Spain. In spite of very heavy weather in the Bay, her ports of call were made exactly to schedule, and she left for New York with a full cargo. The passage across the Atlantic was characterised by almost continuous and occasionally by exceptionally heavy weather, the ship passing through the centre of a violent cyclone, but, under the most adverse conditions, no trouble whatever was experienced with the propelling machinery, and the steadiness of the ship and the absence of any "racing" was most noticeable. The *San Benito* is now on her regular run between Boston and the West Indies and her performance is being carefully watched in the expectation that her economy will prove to be as marked as her seaworthiness.

In the recent annual report of the United Fruit Company the directors say :—

"During the latter part of the year the *San Benito* was put in service, and we are pleased to report, is fully meeting our favourable expectations. This being our initial installation opportunities for minor improvements have naturally developed, consisting principally of items which were conservatively introduced as factors of safety whose cost can now well be eliminated. Our experience leads us to feel that the principle is absolutely sound and a long step in the right direction both for economy and efficiency."

In the foregoing article we have reviewed briefly the subject of electric propulsion for ships from its early stages through the period of comparative adolescence. The discussion of the several ships is not necessarily strictly chronological, and, as is inevitable in a description of this nature, it has not been possible, nor has it been considered essential, to include all vessels so fitted. Sufficient has been written to show that the earlier difficulties have been, in great measure, overcome and that, as shown by the United Fruit Company, in the case of the *San Benito*, satisfactory operating results are capable of attainment. In our concluding article, which we hope to publish shortly, several modern installations will be briefly reviewed, and the subject will be discussed more particularly from the practical operating point of view in the light of the latest available data.

Shipbuilding and the Washington Conference.—There was a distinguished gathering at the dinner given by the Worshipful Company of Shipwrights at the Clothworkers' Hall, London, recently, to the First Lord of the Admiralty, the Right Hon. Lord Lee of Fareham. The Master of the Shipwrights, the Hon. Sir Charles A. Parsons, K.C.B., F.R.S., presided. The toast of "Our Royal and Merchant Navies" was proposed by the Right Hon. Sir Edward Clark, K.C., and in response Lord Lee said that there was really one great service as was proved by the great war. He referred to the building of the cruisers the *Repulse* and the *Renown*, and said they were designed and completed within 18 months of the time of receiving the order. That he believed was a record for shipbuilding in the world. There was no disguising the fact that the naval shipbuilding profession had entered on lean times. It had been a pretty lean time for the last four years, and he was afraid, largely as a result of the Washington Conference, there was a further lean time ahead for another 10 years. He advised those present to keep alive research and design, because they had not seen the last war on this planet.

"Installations of Machinery in Ships at the Fitting-out Basin."—In connection with this paper, recently read before the Greenock Association of Engineers and Shipbuilders, by Mr. H. E. Royston, and published in the March-April issue of the *Channel*, Mr. Royston writes that in our abstract of his paper, which we published on page 265 of our July issue, we reproduced an error in quoting the sight-holes as being ½-in. in diameter. This should have read $\frac{1}{32}$-in. in diameter.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

The Hamburg Experiment Tank.

In a previous article (Werft u. Reederei, December 7, 1921), Dr. Foerster has described the general development and lay-out of the Hamburg experiment tank, which is the largest and one of the most modern in the world. In the present article, Dipl. Ing. Popp describes the whole of the apparatus used in this tank, and also the various methods adopted in the evaluation of the model experiment results. The article has been written to promote confidence in the accuracy of the experiment tank and also with a view to the obtaining of closer co-operation between practice and research. The apparatus in the Hamburg tank has been designed from the experience derived from the earlier tanks and every care has been taken in its construction. The following apparatus is considered in detail. The electric contact system, the model resistance dynometer, the model trim measuring and towing apparatus, the screw dynomometer, the torsiometer, the thrust dynomometer, &c. The second part of the article deals with the actual manipulation of the apparatus, and all corrections for friction and other possible sources of inaccuracy are carefully analysed. The question of self-propelled models being more accurate than the usual combined model at present in use is discussed. The author's opinion is that the existing method though perhaps not so faithfully duplicating the conditions of the full-sized ship as does the self-propelled model, is yet more likely to yield accurate results because of the greater accessibility and reliability of its larger dynomometers. Finally, an example showing the whole process of the evaluation of experiment data for a given model concludes the article. Considerable attention is given to the evaluation of wake and thrust deduction factors, and interesting diagrams are given, showing the individual and joint effects of these factors upon the overall efficiency. Each part of the article is profusely illustrated and much valuable information is placed at the reader's disposal.—*M. Popp. Werft, Reederei, Hafen,* June 7 and 22, 1922, p. 335, 367; 19 pp.; 29 ff.

Wake Values for Single-Screw Vessels.

The method of arriving at the value of the wake factor by means of model experiments is well known, but as these latter are not yet part of everyday designing practice, the wake factor must be taken from some of the well-known publications on the subject, or obtained from the analysis of trial results. In this article, the works of McDermott, Luke, McEntee, Semple and Schaffran are first compared. The comparison shows that the wake values expressed in terms of the block coefficient vary considerably and in no definite manner. Furthermore, a study of the literature brings out the fact that some controversy exists as to the wake factor being smaller in the full-size ship than that obtained from a model experiment. The experience of Schaffran and McEntee does not seem to support this view. In view of the conflicting data the author has analysed the results of some 20 trial trips and he makes some interesting observations. The basis of the main investigation is the Taylor propeller work; and in the values of the Taylor coefficients ρ and δ, only the speed of the propeller relative to the surrounding water is unknown, all the other terms being available from the trial data. By assuming a range of speed, values for the propeller diameter can be obtained for the given mean width and thickness ratios, and from these, by interpolation, the correct value of wake speed can be obtained. The results of this analysis, together with the salient features of the vessel they refer to, are all tabulated. The investigation brings out the fact that the wake factor thus obtained, varies appreciably for a small change, or error, in either the mean width or blade thickness ratios, and also with the same vessel at different speeds. In many cases negative values of wake are obtained for quite high block coefficients. Generally, the wake factor for the Taylor screws is quite small, being practically always below 20 per cent. The disturbing feature of the investigation occurs when the Schaffran and the McEntee published values for wake factors are analysed by the Taylor curves. It was invariably found that the McEntee results were considerably greater and the Schaffran results even greater still than those thus found by analysis. The smallness of the Taylor result may be explained by the smaller wake of the full-size ship, or by the fact that the Taylor propeller, for the same speed and revolutions, absorbs a smaller horse-power than the Froude or Schaffran. The whole investigation shows that the wake factor adopted should be restricted for use with a particular standard series. It shows that the wake values for the Schaffran analysis cannot possibly be applied to the Taylor analysis, and *vice versâ*, but within each of these series it is shown to be possible to deduce a wake or better a correlation factor which may be varied with the block coefficient and which can be used with confidence for the design of future similar propellers. This article forms one of the most important of recent contributions to this most hazy aspect of ship propulsion.—*J. C. A. Schokker,* "*Het Schip,*" June 30, 1922, p. 186; 4 pp., 3 ff.

The Wind Propulsion of Cargo Vessels.

This article forms the conclusion of the series reviewed in our January notes, and deals first of all with the stability of sailing vessels. This is treated in a fairly general manner and the important effect of the ratio of beam to draught upon stability is emphasised. In the light of these considerations of stability, a very rounded form of midship section is proposed, which, producing a rapidly increasing moment of inertia of the waterplane as the vessel inclines, ensures that the angle of heel will be kept within safe limits. The article deals finally with the actual construction of the proposed sailing vessels. Throughout it has been the author's aim to show that the power of the wind may be utilised for the propulsion of cargo vessels without necessitating a large crew for the manipulation of the sails. This is achieved by careful attention to the design of the hull, and especially to the design of lee boards or drop-keels which are proposed to be fitted at the stem and stern and amidships. By these keels, which are of cellular construction, the centre of lateral resistance, can be controlled much more rapidly and simply than the centre of effort of the sail. By careful balancing of the drop-keels they can be controlled by quite small machinery, but, owing to their being of necessity on the centre line of the vessel, the auxiliary machinery for the vessel's propulsion must take the form of a twin-screw installation. Several plans showing the construction of the drop-keels and the neighbouring structure for a vessel of about 6,000 tons displacement are included in the article.—*P. Drosne, Bulletin Techn. du B.V.,* June, 1922, p. 133, 4¼ pp. 6 ff.

Compressorless Diesel Engines.

For many years past attempts have been made to eliminate the attendant complications of air injection in Diesel machinery by developing the simpler methods of solid injection. Dr. Diesel's earliest experiments were carried out without a compressor and on the solid injection principle, but were not successful at the time. In 1903 and 1904, machines on the solid injection system were designed by Trinkler and Haselwand, but both these types have disappeared because of their lack of reliability. The general construction of these types is described in this article. With the introduction of the Brons motor, considerable progress was made. A further improvement is found in the Steinbecker engine, in which, because of the steady supply of fuel to the injection valve, a high mean pressure is obtained and hence for the same power, this engine has a much smaller weight than the Brons engine. Constructional difficulties are, however, still associated with this type, and it is thus not yet in general use. The Price, De la Vergne, and Vicker's engines are briefly referred to, and, finally, the Deutz engine is considered. In this type the high injection pressure of the Vicker's type has not been adopted, but the fuel, being injected axially into the combustion chamber, is assured good ignition by an air vortex produced by the special form of piston head projection. So far, this type has only been used for horizontal engines, but as its fuel consumption is reasonably economical, *i.e.*, from ·45 to ·53 lb. per b.h.p. hour, its ultimate conversion to the marine Diesel type is only a question of time. Diagrams are given of each type of fuel injection valve discussed in the text.—*Schiffbau,* June 7, 1922; p. 1055; 3 pp.; 7 ff.

Multi-Stage Air Compressors for Marine Purposes.

In land work, in the design of multi-stage air compressors, it is usual to distribute the work of compression equally in each stage. In marine work, this can only be done with difficulty because the applications of compressed air in internal-combustion engined vessels are so diverse. In these vessels, air is required for the starting of the main and auxiliary motors and also possibly for the driving of steering gear, winches, pumps, &c., each type of machine requiring

air at a different pressure. This difference of pressure can be obtained by throttling, but as this is very uneconomical, by far the better way is to design the intermediate stages of the compressor so that their working pressure can be directly utilised for the driving of these auxiliaries. The design of the intermediate stages on this principle has been generally a tedious process of trial and error, and to eliminate this process, the author deduces a series of equations whereby compressors may be designed having any pre-determined intermediate pressures. Two examples are worked out in detail, both by the formula and by the application of the ordinary, and also logarithmic pressure-volume diagram. This latter method is especially recommended because of its extreme simplicity and generality.—*Marinebaurat V. Steinen, Werft, Reederei, Hafen*, June 22, 1922, p. 365; 2½ pp.; 2 ff.

Model Experiments on Fishing Vessels.

Similar experiments to the following have already been described in our February and April notes. In this article, Dr. Schaffran gives full particulars of model experiments made on a 50-ton motor fishing vessel, designed by Dr. Oertz, of Hamburg. The particulars of the vessel are as follows:—Length on water line, 51 ft.; breadth, 17·6 ft.; mean draft, 4·7 ft.; block coefficient, ·413; prismatic coefficient, ·535. In this class of vessel, a 35 b.h.p. Gallesen crude oil motor which developed its full power at 450 r.p.m. had to be fitted; and the purpose of the experiments was, as before, to find the economic speed of the vessel and the most suitable size and type of propeller. Experiments were made over a range of speeds from 2 to 7½ knots, both with and without propeller attached; and the results of these experiments are given in a set of very complete diagrams. The limiting economic speed was found to lie between 7 and 7½ knots, and when the motor was developing 35 b.h.p., it was found that, with the most favourable propeller, a speed of 7·03 knots could be obtained. In order that the motor should develop its full power, *i.e.*, when working at 450 r.p.m., a two-bladed propeller of 2·76 ft. diam. with a pitch of 2·14 ft., and having a disc area ratio of ·28 was found to be necessary. This propeller possesses the maximum attainable efficiency of 54 per cent. Experiments made to test the trawling qualities of the vessel showed that when moving at 2 knots, the vessel could tow a load of 1,060 lb. or 30·4 lb. per b.h.p. These latter experiments brought out the considerable advantages of the mechanically-adjustable-pitch propeller, for, in this condition, the maximum efficiency of 20·5 per cent. was given with a pitch of 1·78 ft., whilst with the original pitch, the full revolutions could not be developed, and as a result of the low revolutions the force that can be towed is reduced by as much as 13 per cent. The article is very complete and much valuable information on this class of vessel is contained in it.—*Dr. K. Schaffran, Der Kleinschiffbau*, June 10, 24, 1922; p. 157, 172; 9 pp.; 12 ff.

Electric Welding at the Deutsche Werft, Hamburg.

The efficacy of electric welding for repair work has long been realised, but its use as a definite system in ship construction has but recently been adopted. In Germany, during the war, where the materials for the older system of oxy-acetylene welding were difficult to obtain attention was of necessity directed to the more manifold applications of electric welding. Experience has since shown that electric welding is much more convenient for shipyard use than oxy-acetylene welding, due, of course, to the ease with which current can be obtained in any part of the shipyard as opposed to the clumsy necessity of transporting oxygen bottles and acetylene plant. Formerly, the chief difficulty of electric welding was the securing of a sufficiently small arc to reduce the danger of oxydisation of the metal being welded, but this difficulty has now been overcome. One result of this is that expert welders can now be trained in a much shorter period. Much progress has been effected by a special welding machine manufactured by the A.E.G., brief particulars of which are given in the article. At the present time in the Deutsche Werft electric welding is being used for the connection of a vessel's main structural parts, and thus much riveting and caulking is eliminated. A special shop is being erected in which the welding of boilers, tanks, and ship fittings will be carried out. Tests show that a running weld, 1·52 metres long, can be made per hour, necessitating the using of 24 electrodes, weighing altogether about ·8 kg., the amount of current required being 3·6 kwh. Throughout the article, many interesting photographs are given of the everyday applications of electric welding in the Deutsche Werft, and such a wide-spread use clearly points out the rapidity with which shipbuilding methods are changing in the newer and possibly more up-to-date yards of the world.—*W. Heins, Schiffbau*, June 7, 1922; p. 1062; 4½ pp.; 14 ff.

The Schoop Metal Spraying Device.

The applications of non-corrodible metallic coverings for ship work are legion, and for many years such processes as galvanising have been an established practice. The deciding factor has generally been the size of the galvanising bath, and for this reason, the practice of pickling ship plates is now but rarely adopted. With the metallic sprayers designed by the author no such limitations exist and any metallic covering can be carried out. This sprayer or Electro-Metallisator Pistol as it is called consists of two wire electrodes of the metal to be sprayed, through which is passed an electric current at 20 to 40 volts. The ends of the wires are so arranged as to produce a small arc, thus melting their constituent metal. The molten metal is then blown on to the surface to be covered by an air jet of some 3½ to 4 atmospheres pressure. Actual results have shown the method to be very economical, both compared with the similar method in which the metal is melted by an oxy-acetylene flame, and with the ordinary galvanising process. By this electric method the adherence of the covering is said to be greatly superior to that produced by the other methods, and this has been verified by torsion tests. The low temperature of the spray enables the method to be safely applied to those metals which are very sensitive to heat treatment. One important possible application of the method is in the calorisation of metals. As is fairly well-known, this consists of covering with a layer of aluminium such metallic parts of machines, &c., which, through heat and moisture, are subject to excessive corrosion. Protection from ordinary as well as high temperature corrosion is one of the most important of shipyard processes and the metal sprayer will undoubtedly come into more general use as its reliability is tested and assured.—*M. U. Schoop, Schiffbau*, June 21, 1922; p. 1106; 1½ pp.; 1 f.

Vibrations of Turbo-Generator Seating.

In a previous article the author has shown by application of the vibrograph that the vibrations in the seating or foundation of a turbo-generator may be quite considerable. The foundation of this class of machinery generally consists of skeleton supports firmly connected to the main bed plate. Vibration is only likely to occur in this skeleton structure when resonance takes place with the revolutions of the turbine. The critical period of vibration of each constituent part of the structure can be examined by the usual complete graphical treatment, but as this is very complicated, the author sets himself the task of deducing simple formulae based upon reasonable assumptions which will enable designers to avoid the excessive vibration associated with resonance. Distinct formulae are set up for the several possible forms of the structural vibration, and by manipulation of these the scantlings of the structure can be arranged to eliminate any likelihood of the occurrence of the particular form of vibration. The author recommends that, where possible, these individual vibration periods should not approach within 30 per cent. of the working speed of the turbine itself. In difficult cases the instrument, or vibrograph as it is called, designed by the author, should be utilised to analyse any troublesome vibration.—*Dr. J. Geiger, Z.d., V.d. I.*, July 1, 1922; p. 667; 2¼ pp.; 5 ff.

The T.S.S. "Hansa."

This vessel has been the object of many conversions. Built originally as the *Deutschland*, by the Stettiner Vulcan in 1900, as a high-speed transatlantic liner, it was converted in 1910-11 for Mediterranean pleasure cruises and given the name *Victoria Luise*. In this conversion, half the boilers were removed and the engine-power reduced to give the vessel a smaller speed. The elimination of the after boilers enabled a swimming bath to be fitted. During the war, the vessel was intended to be used as an auxiliary cruiser, and after the cessation of hostilities the Hamburg-Amerika Co. decided to re-introduce it into their Hamburg-New York service. The necessary conversion was carried out by the Vulcan Werke at Hamburg, and also by the Stettiner Company. The vessel was completely overhauled and all the boilers fitted out with oil-burning apparatus. The converted vessel, now the *Hansa*, was completed October 27, 1921. The principal dimensions of the vessel are as follows:—Length B.P., 660 ft.; beam, 66·5 ft.; depth to upper deck, 43·8 ft.; draft, 30·5 ft.; displacement, 25,170 tons; dead-weight, 8,500 tons. The vessel is now of the intermediate class, and in this article the main constructional features of the vessel are very fully described. The bulk of the article deals with the oil-burning installation and this description should form a valuable source of information for those interested in what is probably the latest German practice in this class of work. An interesting comparison of the constituent weights of the original *Deutschland* and the *Hansa* concludes the article.—*P. Hein, Werft, Reederei, Hafen*, May 7, 1922; p. 263; 10 pp.; 23 ff.

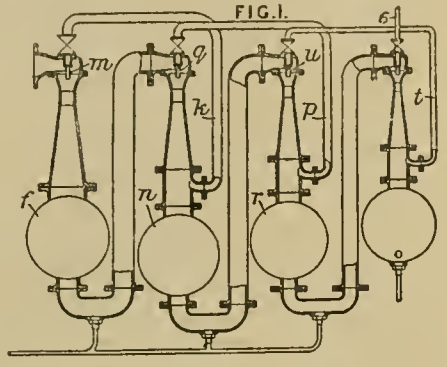
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 179,976. Ejectors.

Weir, Limited, G. & J., and Weir, J. G., Holm Foundry, Cathcart, Glasgow. January 12, 1921, *No.* 1,837. [*Class* 71.]

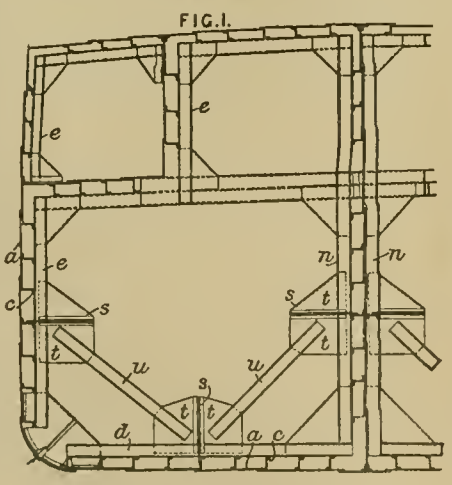
Intercondensers *f*, *n*, *r* are employed between the several stages of a multi-stage air ejector of the kind wherein steam is used as the inducing-fluid in the last ejector 6 of the series and in which some of the discharge from one or more of the ejectors is used as the ejector fluid in one or more of the ejectors earlier in the series. In the arrangement shown, the ejectors *u*, *q*, *m* are supplied with fluid taken from the discharge of the next stage following in the series by means of the pipes *t*, *p*, *k*, respectively. The condensate from each condenser is led off by pipes communicating with the main condenser. In a modified arrangement, ejector fluid for the previous stages is taken from the discharge of the last stage ejector by means of the pipe *t*, which is connected with each of the ejectors earlier in the series. Or the fluid taken from the discharge of an ejector and used in an earlier ejector may be mixed with fluid taken from the discharge of another ejector later in the series.



No. 180,158. Ships.

Munro, J. M., 41, *Hawthorn Street, and McGill, A.*, 70, *Hugh Gardens, Newcastle-on-Tyne. April* 12, 1921, *No.* 10,715. [*Class* 113 (ii).]

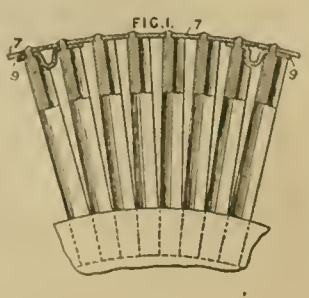
In a ship construction in which the plating of the shell, bulkheads and decks is of **Z**-cross-section with one flange *a* much extended and the short flange *c* riveted to the side and bottom frames *e*, *d*, diagonal channnel bars *u* are employed to connect the vertical and transverse frames *e*, *d*, *n* of the sides and bulkheads, the stays being attached to brackets *e* which connect the fore-and-aft brackets *s* to the frames.



No. 180,216. Turbines.

British Thomson-Houston Co. Limited, 83, *Cannon Street, London.—(General Electric Co.; Schenectady, New York, U.S.A.) May* 31, 1921, *No.* 15,129. [*Class* 110 (iii).]

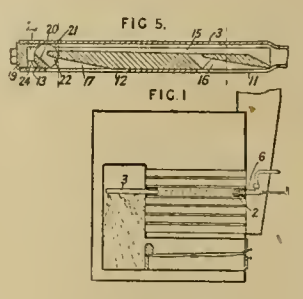
A shrouding-device for the blades of elastic-fluid turbines in which the blades of each ring are tied together in groups by separate shroud covers comprises means for connecting these shroud covers by flexible connections located directly beneath the adjacent ends of the shroud-cover sections. In the form shown in Fig. 1 the shroud sections 7 are connected by U-shaped plates 9, which are sufficiently stiff to prevent vibration, but are bent to allow expansion and contraction. The blades are riveted to the shrouding, and holes are formed in the plates 9, through which pass the tenons that hold the shroud sections. In another form the U-shaped plates may be fixed to the shrouding by separate rivets.



No. 180,424. Cleaning Boiler Tubes.

Westerberg, C. A. A., 10, *Kungsträdgardsgatan, Stockholm. February* 22, 1921, *No.* 5,924. [*Class* 99 (ii).]

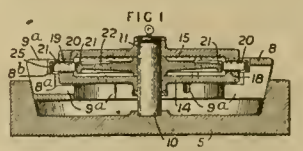
Relates to apparatus for cleaning boiler tubes by means of steam jets directed from nozzles mounted in a steam-pipe adapted to be rotated about its axis, and consists in so arranging the nozzles that the directions of the jets from adjacent nozzles intersect before reaching the tube plate. In the form shown in position for cleaning in Fig. 1 and in detail in Fig. 5, the steam-pipe 2, having a widened end 3 containing the nozzles, is mounted for axial and rotational movement within a boiler tube, the end 3 being withdrawn into the tube when in the inoperative position. Steam, admitted to the pipe 2 by the apertures 6, enters the channel 15 and escapes in the form of jets through the channel 16 and aperture 11, the channels 21, 22, 17 and aperture 12, and the channels 21, 23, 24 and aperture 13. The ball 20 may be adjusted by unscrewing the plug 19 to vary the width of the jet from aperture 12. In a modification, the nozzle end 3 of the pipe may be made in a single piece, preferably of cast iron.



No. 180,581. Turbines, &c.

British Thomson-Houston Co. Limited, 83, *Cannon Street, London.—(General Electric Co.; Schenectady, New York, U.S.A.) June* 29, 1921, *No.* 17,721. [*Classes* 83 (ii), 83 (iv), *and* 110 (iii).]

Blades, vanes, nozzles and the like.—A ring of buckets 20, held in close proximity to a rotor wheel 22 by holders 14, 15, is fixed in place by a shrouding-ring 25, forced and shrunk round the blades 20. The complete bucket-wheel is then firmly united by fusion of metal. The wheel 22 is positioned between the holders 14, 15 on a post 11 and the buckets are placed in position in slots 18, 19 in the holders. The post is then lowered into a recess 10 in a cylindrical vase 5, the lower holder 14 resting on a ledge 8^a in a compressible ring 8, fitting in the base. The ring 8 has radial slots 9^a extending from either side alternately. A heated shrouding-ring 25 is placed round the buckets on the ledge 8^b and the ring 8 is forced into the base 5, thus compressing the ring 25 on to the buckets, so that hardened projections 21 on the latter are forced into the wheel and the shrouding-ring. The bucket-wheel is then removed and the parts are firmly united by fusion of metal.



OFFICIAL NOTICES.

THE Proprietors of the Patent No. 152333 for "Sounding Apparatus for Submarine Boats" are desirous of entering into arrangements by way of licence and otherwise, on reasonable terms, for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to Haseltine, Lake & Co., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

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MARINE Engineer wanted at Liverpool, Bristol, Cardiff, Swansea, and other ports, to sell new boiler fluid for use with sea water. Salary and commission. Apply, with copies of references, to Box 20, *c/o Marine Engineer*, 33, Tothill Street, S.W.1.

The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES WELDING & MECHANICAL REPAIRS
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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

Vol. XLV. No. 540. September, 1922.

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The death took place in Dublin, on July 28, of Mr. Holt Worthington, J.P., promoter of the Galway-Barna transatlantic schemes of 1911–1914, which never came to fruition.

The death occurred on July 30, at the Langham Hotel, London, W., of Mr. Peter Donaldson Haggart, Secretary of the Adelaide Steamship Company, Limited.

Mr. George Henry Jackson, of Sanderstead, Surrey, a partner in the firm of H. E. Moss & Co., shipbrokers, St. Mary Axe, London, E.C., and Liverpool and Newcastle, has left estate of the gross value of £53,743.

Mr. Gordon Dodd and Mr. George Allan, two well-known and popular surveyors for Lloyd's Register of Shipping at New York, have been transferred, the former to Galveston, Texas, and the latter to Balboa, Panama Canal zone.

Mr. James Bain, a former superintendent engineer of the Cunard Steam Ship Company Limited, who died at Hexham, near Newcastle-on-Tyne, in June last, has left estate of the gross value of £14,129.

Sir Ernest M. Raeburn, K.B.E., who died in New York in June last, aged 43 years, son of Sir William H. Raeburn, M.P., and lately Director-General of the British Ministry of Shipping in New York, and formerly a partner in the firm of Raeburn & Verel, shipowners, Glasgow, has left personal estate of the total value of £39,198, of which the personal estate in the United Kingdom amounts to £38,952.

Sir William Nelson, Bart., who died in July last at the age of 71 years, founder of the Nelson Line (Liverpool) Limited, the Nelson Line (London) Limited, and the Nelson Steam Navigation Company Limited, left gross estate of the value of £992,751, the net personalty being £831,499. He left £1,000 each to his private secretary, H. Cutler Smith, and to Mr. Arthur R. T. Woods, of Leadenhall Street, E.C.

Mr. Thomas Braidwood, Superintendent Engineer of the Coast Lines Limited and Associated Companies, was recently the recipient of a series of presentations to mark the occasion of his marriage. The presentations were made by Mr. M. H. Hulme, General Manager, on behalf of the office staffs, and consisted of a piano from the captains, officers and engineers, a chiming clock from the superintendents, and a canteen of cut-glass ware from the office staffs.

The funeral took place on July 29, at Wallasey, of a famous old Cunard Commander, Captain Thomas C. Dutton, in the presence of many of his old shipmates. The captain, who was in his 82nd year, joined the Cunard Company in 1871 as a junior officer, and was promoted to command in 1880. As Master of the *Umbria* he travelled over 800,000 miles of ocean, and for his services during the South African War he received the Transport Medal. He also possessed a gold medal for rescuing the crew of the French barque *Jean Baptiste* in 1895.

Mr. Sam Thomas, J.P., who for over 30 years had been Superintendent and Dock Master of Penarth Dock and Harbour, was on July 29 presented with a silver tea and coffee service by the staff on the occasion of his retirement. Mr. Thomas, in thanking the staff, said he was proud to be associated with the Penarth Dock, which was not a large dock when compared with the adjacent docks. The Penarth Dock area represented about 8 per cent. of the Customs Port of Cardiff, namely, Cardiff, Penarth and Barry, but Penarth handled about 20 per cent. of the trade of the port.

The refrigerating machinery industry loses, by the death of Mr. William Bernard Godfrey, which took place recently at Hindhead, one of those who took a prominent part in its early development. He was the youngest son of the late Mr. Joseph Sylvester Godfrey, of the Middle Temple, was educated at Winchester College, and served his apprenticeship with Quick & Son. In 1876 and 1877 he was assistant engineer in the construction of the first steam tramways in Paris, and from 1878 to 1880 was erecting for the Lontin Electric Light Company some of the first public electric lighting installations in London, notably at the old Gaiety Theatre and the Opera House. In 1881 Mr. Godfrey became a partner with Mr. Everard Hesketh in the works of J. & E. Hall at Dartford, and together they developed an important business as makers of refrigerating machinery, and were engaged from the earliest days of the industry in fitting out ships for the importation of frozen meat. In 1888, the late Mr. Alexander Marcet joined the firm, and after much experimenting they developed the CO_2 refrigerating machine into the practical machine as it exists to-day. At the formation of the present Company, in 1900, Mr. Godfrey continued as director in charge of the financial department until his retirement in 1910. He also took part in the more recent developments of the commercial motor vehicle side of the work.

EDITORIAL.

THE COMING-OF-AGE OF THE MARINE STEAM TURBINE.

IT is often a matter of considerable difficulty to fix upon an exact date when a new idea may be said to have been definitely adopted for commercial purposes, but students of engineering history—and there are many such—will probably be unanimous in fixing the year 1901 as the date when the steam turbine was definitely accepted as a suitable form of engine for the propulsion of merchant ships. Previous to that date, of course, interest in the engineering world had been raised to a high pitch of expectancy by the wonderful performances of the *Turbinia*, the little launch that had been fitted by Sir Charles Parsons with turbines of his own design. Experimental work with this little vessel was carried out during the years 1894-97, and as a result of the experience thus gained, the immense possibilities of the steam turbine were clearly indicated. Further, the British Admiralty had shown their faith in the possibilities of the marine steam turbine by equipping two torpedo-boat destroyers, the *Viper* and the *Cobra*, with this method of propulsion. Unfortunately, both of these vessels were lost at sea, and while in neither case was the accident in any way connected with the fact that the vessels were driven by steam turbines—unless, indeed, it were that the speed was too high for the strength of the hull—the prospects of the marine steam turbine received a setback as a result of these disasters.

It was in the year 1901 that the first commercial steamer propelled by steam turbines made her appearance. This was the Clyde pleasure steamer, the *King Edward*, built by W. Denny & Bros., at Dumbarton, and engined by the Parsons Marine Steam Turbine Company. This vessel was in service during the summer season of 1901, and fully justified the faith of the designers in the possibilities of the new system of propulsion. It was recognised that for the propulsion of high-speed vessels—that is, for vessels where a high propeller speed could be economically employed—the economy of the steam turbine was very marked, and both of the railway companies operating steamboat services from this country to the continent were persuaded to instal steam turbines in new vessels which they were then adding to their fleets. In 1903 *The Queen* was added to the cross-channel service of the South Eastern and Chatham Railway, and in the same year the Brighton Railway, in conjunction with the French State Railways, added the *Brighton* to their fleet. Both of these vessels were built by Denny's, and engined by the Parsons Marine Steam Turbine Company, and they were the forerunners of many turbine-driven steamers for their respective owners.

From that time onward, the development of the marine turbine was very rapid, both in the number of vessels so equipped, and in the size of the individual units. After having shown its merits on cross-channel steamers, the steam turbine was tried on fast ocean-going liners, in 1905 the Allan Line, as it then was, ordering two vessels—the *Victorian* and the *Virginian*—both of which were propelled by steam turbines. The former vessel was built and engined by Workman, Clark & Co., and the latter by A. Stephen & Sons, and engined by Parsons. The Cunard Company made the notable experiment of building two similar boats, one the *Caronia*, propelled by two quadruple-expansion engines, and the other the *Carmania*, propelled by steam turbines. Both of these vessels were built by J. Brown & Co., in 1905, and as the subsequent history of the Cunard Line shows, the steam turbine proved its superiority over the reciprocating engine, for all the subsequent high-speed Atlantic liners built for the company have been propelled by the former type of machinery, among them the *Mauretania* and the ill-fated *Lusitania*, built in 1907, and the *Aquitania*, all of which were equipped with direct-coupled turbines.

The subsequent history of the marine steam turbine is too recent to need detailed attention. Mention must, however, be made of the *Vespasian*, which, in 1910, was equipped with speed-reduction gearing. This enabled the speed of the turbine to be reduced, so as to yield an efficient propeller speed, and thus rendered possible the use of turbines for the propulsion of slow-speed cargo boats and intermediate liners.

FUNCTIONS OF THE FOREMAN.

THE works foreman in charge of a department in a shipyard or engineering works must be a man of sound practical experience. It is essential that he should have a good initial training, as mere opportunity without ability will not produce a successful foreman, and further, he should possess a good education. Clear thinking and good organisation can help a poor plant, and better results can be obtained than with a good plant badly managed. It is possible to summarise the essential requirements of a head foreman as consisting of "foresight," "co-ordination," "supervision," "command" and "diplomacy," combined with "push" and a thorough knowledge of all the details of the department under his charge. Organisation based on the concentration of powers under one head is superior to organisation based on dual control if unity of thought and action is to be attained. Certain qualities, such as activity of mind, courage of conviction, knowledge of the technicalities of the work, and general business experience are essential in order to use foresight to advantage.

In a well co-ordinated shipyard it will be noticeable that each department co-operates with the other, and that all departments arrange their work and orders to dovetail, as it were, with other departments, all with the one object in view, namely, the completion of the vessel under the most ideal conditions. Control consists of verifying whether things develop according to the programme arranged, the orders given and the systems adopted; it aims at the discovery of errors and avoiding them in the future. Control can only be established over the barest operations as the result of close and constant inspection, and it should be followed by prompt approval or disapproval as found necessary. Should control be applied too late, supervision is useless and a waste of time. Human effort regulates the efficiency of all plants and machinery, obviating waste, and it may add new resources. Efficiency of plant and machinery is open to further development in most yards, and this should always be kept in view by all foremen.

Owing to insufficient knowledge of the underlying principles ruling industry, the average worker is prone to believe that the extra profit obtained from improvements goes to the employer without a corresponding advantage to himself. It therefore behoves the foreman to show his men that improvements which aim at an increase and better quality of production with equal or less effort, are as beneficial to employee as to employer. The thoughtful distribution of labour should receive most careful attention. A worker always employed doing the same operations becomes more efficient, and better workmanship and faster output is attained with less effort than if he were employed on a variety of different operations. This allows the foreman's time perhaps to be better employed as his close attention is not necessary. Division of labour resulting in specialisation is the best means of employing large numbers of men. Sometimes it has its limit, but an experienced foreman is able to define this limit. No employee should receive instructions from more than one foreman. If this is not adhered to, efficiency of control is lost. Dual control is a principle antagonistic to proper organisation, and experienced management will not create or tolerate such.

The foreman should always remember that private interests should be kept in subordination. The interests of any employee

or group of employees must not dominate the progress of the work as a whole. The protection of individual interests is a weakness which human nature many a time tends toward, but equity and justice must govern all good administration. Initiative is a quality all foremen should possess, combined with plenty of energy, common sense and experience. It is his duty to establish a principle strongly as a policy to be followed by all under him. There is an art and diplomacy in the creation of stability and union of the employees under him, and this can be secured by proper management.

To all who aspire to positions of trust and responsibility, administrative capacity is an essential asset, and this subject should form a greater part of their training and education than at present. The foreman must at all times have a consistent programme of action, he must forecast the run of the undertaking. Constant changes in giving orders must not be adopted if he wishes to work economically the department under his charge. Foresight based on his past experience and education will be the line of conduct and means he will adopt to make his position a success.

TECHNIQUE IN DESIGN.

SHIPOWNING may be said to consist of two distinct operations : (*a*) the purchase of a vessel or vessels, and (*b*) the management of the fleet. While there can be no doubt that in operation (*b*) the British shipowner is second to none, it is equally certain that in the specification of the vessel which will satisfy his requirements the same grasp of fundamental principles is not so evident. The ideal shipowner is, of course, one who combines a sound technical training in naval architecture and marine engineering with his commercial attainments ; or alternatively, one who employs such a person as his representative. It is not advisable to rely alone on the services of the marine superintendent, who, in nine cases out of ten, is a retired sea-going engineer, for that intimate knowledge of scientific ship-design which is now more than ever desirable. An instance has come to our notice of faulty design, which is almost as glaring as a revoke at bridge. A vessel of a certain size, form, power and speed was constructed and placed on service and proved in every way satisfactory. The owners then ordered a sister vessel *of the same form*, but lower power and speed. Obviously, one of these vessels is inferior to the other as a commercial proposition. It is highly probable that neither of them is the vessel best suited to the owner's requirements. The process of design is here essentially one of " trial and error " when, by careful investigation on scientific lines, a direct determination of the most satisfactory design might have been arrived at. From the data before us it is evident that a higher block coefficient should have been associated with the slower speed in the case of the second vessel instead of adopting the same form as the faster boat.

A sound technical knowledge would yield the shipowner good service, not only in the design and specification of his vessels, but also in the correct analysis of trial trip results, which are otherwise, we should imagine, not of any direct value to him. Even more valuable than this would be the opportunities for service trials under ordinary sea conditions. It would be possible to direct, and, perhaps, personally superintend such trials, and results should be obtained which should be of the highest value, not only to the shipowner himself, but, ultimately, to the whole community. There is much yet to be learnt in connection with the effect of waves on resistance—how the form which gives the best results under tank conditions should be modified to give the best results at sea—the effect of rolling, pitching, heaving and yawing, on resistance and propeller efficieney—in short, the final investigation of the way of a ship upon the sea rather than of a model in a tank.

INSTITUTE OF MARINE ENGINEERS.

Programme of Winter Session.

The Session will be re-opened on Tuesday, September 12, by Sir George G. Goodwin, K.C.B., who is arranging to deliver his presidential address on that evening at 6.30. The following papers have been arranged :—

Tuesday, September 12, 6.30—The President's Address.

Tuesday, September 26, 6.30—Views illustrating Industrial Work. Films lent by Messrs. Vickers, Barrow.

Tuesday, October 10, 6.30—" Conditions to observe to get high efficiency from Oil Fuel," by Alberto Keenes (Member).

Tuesday, October 24, 6.30—Views illustrating Industrial Work.

Tuesday, November 14, 6.30—" The Evolution of the Nobel-Diesel Engine," by G. J. Steinheil, B.Sc.

Tuesday, November 28, 6.30—Views illustrating Industrial Work.

Tuesday, December 5, 6.30—

Tuesday, December 19, 6.30—Views illustrating Industrial Work.

The British Cast Iron Research Association.

A number of investigations of a varied character have been carried out on behalf of the members of the Association. Most of these are of general interest and importance and provide valuable data in connection with the larger research works which are being carried out by the director. The research work in connection with draws and shrinkages, moulding sands and refractories, internal-combustion engine cylinder castings and methods of testing cast-iron are being pushed forward, and very valuable data collected. A special committee has been appointed to carry out a thorough investigation in connection with malleable iron castings with the view of broadening out the use of this class of casting.

Foamite on Board Ship.

Foamite Firefoam Limited have received further testimony to the value of Foamite Firefoam as an extinguisher of accidental oil fires. The captain of an oil-burning vessel belonging to an important steamship company has sent the following report to his owners. " I regret to report an outbreak of fire in No. 1 stokehold at 10.30 p.m. on 6th inst. The boiler attendant when changing burners neglected to screw up same. He inserted the torch to light up and on opening the valve the hot oil blown out caused him to withdraw and drop the torch, which ignited the oil in the tray on the tank top. The engineer on watch promptly stopped the oil-fuel pump and gave the alarm to the chief engineer who immediately ran down to the stokehold with several other engineers who happened to be in the mess room at supper, and proceeded to smother the flames with Foamite. The Foamite sprays proved very successful in dealing with the fire, the flames being extinguished by the prompt use of them before any material damage was done except to some electric wiring in the stokehold." In forwarding the report to Foamite Firefoam Limited, the manager of the shipping company states that he is " very pleased to hear of this example of the efficiency of your extinguisher."

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

The All-Electric Age. By Adam Gowans White, B.Sc., A.I.E.E. London: Constable & Co., Limited. 242 + XIII pages. Numerous illustrations. Price 7s. 6d.

In this book the author has succeeded in presenting a comprehensive review of the manifold applications of electricity in attractive phraseology, entirely free from involved technical dissertation. The growth of the central power-station and the coming of the super-station are reviewed, and the varied application of electricity to commercial traction and industrial production is discussed. To the layman much of popular interest will be found in the book, and he will be able to appreciate by the written word and by illustration how the health, cleanliness and comfort of the home may be enhanced by the use of electricity for such purposes as lighting, heating, cooking, washing, and cleaning.

Motorship Year Book, 1922. By Miller, Freeman & Co. (Publishers of *Motorship*). 282, West Twenty-Fifth Street, New York. $7\frac{1}{2}$ in. × $10\frac{1}{2}$ in. × $\frac{5}{8}$ in. 127 pages. Price $2.00.

In this book a considerable amount of useful information relating to the design, construction and general development of the marine Diesel engine has been brought together. Lloyd's Revised Rules for the Construction and Survey of Diesel Engines, and also the American Bureau of Shipping Rules for Construction of Marine Internal Combustion Engines have been included, and a specimen set of questions and answers, suitable for a candidate preparing for his Licence examination, is given. American and European motorship construction during 1921 is briefly reviewed, and a series of interesting articles relating to Diesel engine structural features and various fuels is also submitted. A list of marine Diesel engine and surface ignition oil engine builders throughout the world is given, and a complete index of all motorships of the world has been included. The book is attractively written and profusely illustrated.

The Mechanical Handling and Storing of Material. (Third edition.) By G. F. Zimmer, A.M.Inst.C.E. London: Crosby Lockwood & Son, Ludgate Hill, E.C. 4. 1922. $10\frac{1}{2}$ in. × $7\frac{1}{2}$ in. × 2 in. 795 + xx pp. More than 1,100 illustrations. Price 63s. net.

Originally published as "The Mechanical Handling of Material," in 1905 this book, was revised and brought up to date in 1916 under the title of "The Mechanical Handling and Storing of Material," as the author found that with the advance of time the storing and reclaiming of material was inseparable from mechanical handling. This most comprehensive treatise is manifestly, as Mr. Zimmer has stated, "not the work of a day, a month, or a year," but may truly be said to represent practically a lifetime's study and practical experience of everything appertaining to the subject. A desirable feature of the third edition is that, whereas in the first two editions it had been necessary, in order to give a representative array of typical examples to draw upon Continental and American practice, such descriptions have, wherever practicable, been replaced by examples of British manufacture.

All matter of historical interest in the development of the subject has been retained and obsolete devices devoid of such interest have been deleted and replaced by modern examples. Only those latest examples which may safely be said to have passed the experimental stage have been added, and, working on these lines, the author has brought the entire book completely up to date, chronologically arranged in accordance with progressive development. Every aspect of this very wide subject, including the Archimedean screw, pneumatic and hydraulic appliances, aerial ropeways, coaling ships at sea, &c., &c., has been fully and authoritatively dealt with.

Schiffshilfsmaschinen. (Part I, second edition.) By Dipl. Ing. A. Achenbach. Leipzig: Verlag von Dr. Max Jänecke, Hospital Str. 10. $8\frac{1}{4}$ in. × $5\frac{1}{2}$ in. × $\frac{1}{2}$ in. 295 pp. 346 ff. (Price uncertain).

The subject of the design of ships' auxiliary machinery has received but scant treatment in our technical societies, our technical press and in our standard text books on marine engineering. A similar state of affairs existed in Germany, and to remedy this the author has produced an exceedingly useful little text book on the subject. The book is divided into three parts, the first two dealing with hoisting machinery and fittings, such as chains, ropes, pulleys, hand and steam winches, &c., whilst the third deals with the design of reciprocating pumps of all descriptions and purposes; centrifugal pumps, ejectors and pulsometers. The treatment throughout is very thorough and should prove of considerable value to both ship and engine draughtsmen. Not only is the subject considered technically, but considerable data of German practice is given. Care seems to have been taken in this connection to specify the actual weights of all items described. A supplement dealing with the construction of the German standard ship winch forms a useful addition to the book. We can confidently recommend the work to all interested in the construction of ships' auxiliary machinery.

TRADE PUBLICATIONS.

Ships' Auxiliaries.—We have received from R. Roger & Co. Limited, of Stockton-on-Tees, copies of the *Roger Journal* for March-April and May-June. 1922. In these two eight-page booklets the products of this firm are listed, and, in a few cases, illustrated. These products comprise an extensive range of winches for all purposes, including cargo, trawl, whaler, dredger and coal shipping winches, &c., also steering gears, capstans and deck cranes. Several pages of these booklets are devoted to the brief discussion of items of light, popular interest, and ancient sea lore.

Scrap Shears.—A catalogue of scrap shears with guaranteed unbreakable steel plate frames has been published by Henry Pels & Co., 1, Boymansstraat, Rotterdam. The shears are designed for cutting up all kinds of scrap metal, and can be supplied skewed shear blades or with the blade at right angles to the frame and with any depth of throat desired. The standard machines are made in eight sizes; the largest will cut plates up to 2 in. thick, the depth of throat being 24 in. One machine shown in the catalogue, a combined billet and scrap shears, will cut slabs up to 8 × $3\frac{1}{4}$ and joists up to 12 × 5 × 32 lb.

English Electric Company Limited.—Two new publications entitled "English Electric Cam-Shaft for Electric Locomotives" and "The Blackburn East Power Station," respectively, have been received from this company. In the former, this method of control applied to a locomotive equipped with four 350 h.p. motors is described, and the complete apparatus is illustrated, while in the latter, a comprehensive review is made of the lay-out and plant of the new Blackburn (East) Power Station. The English Electric Company were the successful tenderers for the provision of all the plant, the foundations and the structures necessary for this power station, which, it is stated, is the first of the large stations to be erected under the provisions of the Electricity Act.

THE TWENTY-FIRST ANNIVERSARY OF THE COMMERCIAL MARINE STEAM TURBINE.

The "King Edward" Experiment—Influence of Naval Design—The North Atlantic Liners—Problems of Design—Operation—Gearing.

It is just 21 years ago that the Clyde pleasure steamer *King Edward*, the first commercial vessel propelled by turbine machinery, completed with brilliant success her first year's service. Almost simultaneously—in July and September, 1901—the total loss of the first two turbine-driven warships, H.M. torpedo boat destroyers *Viper* and *Cobra*, which, with the exception of the original experimental launch *Turbinia*, were the only other ships in which turbines were then installed, left the *King Edward* as the solitary example of a type of marine propulsion which has since run into figures far exceeding 50,000,000 h.p. fitted in naval and mercantile vessels throughout the world. The *King Edward* continues in useful service to-day, and is likely to do so for many years.

When the truly colossal development of the marine turbine is considered in retrospect the first few years of its short history must be regarded in many ways as being of the greatest importance. During the war period many millions of marine horse-power were installed with less diffidence and interest than were evinced over the few individual sets in those early years. Rapid acceptance of the new motor did not begin to be general in Great Britain until 1905, while, with a few isolated exceptions, turbine machinery was not adopted by foreign nations until two or three years afterwards. In spite of the excellent performance of the *King Edward* the loss of the destroyers produced a markedly adverse result on turbine development. Her owners promptly ordered a second very similar vessel, the *Queen Alexandra*; the British Admiralty ordered first one and then a second destroyer, and then the light cruiser *Amethyst*, but pending the completion and trials of these vessels there was a distinct air of reluctance to accept the new motor. As the result of experience with the destroyers, the late Mr. J. R. Perrett, for many years the chief naval designer at Elswick, tried very hard to get turbines introduced in the scout-cruisers of the "Attentive"-class, built by Sir W. G. Armstrong, Whitworth & Co. in 1902-3, but with the exception of the *Amethyst*, in England, and the *Lubeck*, a cruiser of similar type, in Germany, orders for anything larger than destroyers were at first confined to vessels of the cross-channel type.

Lack of Data.

Very little information as to the performance of these ships was available in the earliest days of the marine turbine, and it was not until the end of 1904, when the results of the comparative trials between the *Amethyst* and the reciprocating engined sister-ship *Topaz*, were published, that complete data on the relative performance of vessels fitted with the two types of engine was forthcoming in any detail. Simultaneously, similar information regarding the comparative trials of the Midland Railway Company's vessels of the "Londonderry" type, with turbines, and the piston-engined sister ships was made public, and only from this date onwards the real development of the marine steam turbine may be said to have begun.

It was the British naval programme of 1905-6 that gave the marine turbine its tremendous start on the way to the colossal horse-power output which it has since attained, and the importance of the step then taken must always figure as one of the greatest developments which has ever been witnessed in marine engineering. By this time the *King Edward* had run for five and the *Queen Alexandra* for four seasons with conspicuous success, covering over 160,000 miles between them without a hitch. The performances of various yachts, one of which, the *Emerald*, was the first turbine steamer to cross the North Atlantic, coupled with the superiority of various channel steamers fitted with turbines over their reciprocating opposite numbers on the same services, had justified first the Allan Line and then the Cunard Company in adopting marine turbines, but very great credit must be assigned to the Engineering Department of the Admiralty for the boldness of the step, which has since been so thoroughly justified, for undertaking the transition from reciprocating to turbine machinery at such a comparatively early stage in the development of the turbine. The historic 1905-6 programme contained H.M.S. *Dreadnought*, of 27,000 s.h.p.; the three "Invincible" class battle-cruisers of 41,000 s.h.p.; five "Tribal" class destroyers which developed 21,000 h.p. each on trial; H.M.S. *Swift* which developed 48,000 s.h.p., and reached 35·3 knots on trial, and a dozen coastal destroyers of 3,600 each. The total developed shaft horse-power in this one programme was nearly 350,000, and at the beginning of 1905 the total horse-power of marine turbines installed to that date was about half this amount. Since then the advance in horse-power has been so rapid as to render precise calculation of the aggregate a matter of difficulty.

The Early Problems.

Most of the problems which arose in the design of the early marine turbine sets had been encountered, and the direction in which the solution lay, clearly discerned during the experimental trials of the little *Turbinia* between 1894-97. The nature of these was very far-reaching and has affected practically all subsequent turbine work. The most important was the then complex problem of harmonising the speed of rotation of the essentially high-speed turbine with propeller dimensions capable of rendering sufficient return from the power delivered to them, and prior to 1905 no suitable device for accurately measuring this power was evolved. Next came structural difficulties, and these, whether in design or manufacture, only arose in 1904 when the Cunard Company placed the order for the *Carmania* with John Brown & Co. Some idea of their magnitude may be gauged from the fact that each low-pressure turbine in this vessel weighed about 350 tons compared with 78 of the Allan liners, the next largest under construction, and about 30 tons for *The Queen*, which was the largest in actual operation afloat. Pessimists of the "It's never-been-done-before" order are of little assistance in work of this nature! Finally, with the increase in number and type of installations afloat came the operating troubles, some of them extremely unexpected in their action. The history of the marine turbine in its direct-connected form covered only the years 1901-11, or from the *King Edward* to the *Aquitania*. All these problems had been met and overcome during this period, and then, in 1909-10, Sir Charles Parsons introduced the geared turbine, involving a fresh development almost as radical as the introduction of his compound turbine years before. Nor is it too much to say that when he introduced the geared turbine in the *Vespasian*, other types of turbine were represented afloat to a very limited extent.

Turbine Proportions.

When the *Turbinia* was first built she was fitted with one turbine driving a single shaft and one propeller, and reached

a speed of only about 20 knots. In order to obtain a turbine sufficiently light and small, very high revolutions (2,500) were adopted, and a single screw of corresponding dimensions proved hopelessly inefficient. This difficulty almost frustrated attempts to introduce the marine turbine, and certainly delayed it. How it was overcome is of importance.

Thermal Efficiency.

In order to obtain thermal efficiency in the turbine between given pressure limits it is necessary to subdivide the heat drop by the introduction of a sufficient number of stages or rows of blades to ensure that the steam-speed due to the heat drop (which is equal, roughly, to 221 $\sqrt{\text{B.T.U. drop}}$) shall bear a certain relation to the blade-speed. This fundamental consideration is the main factor governing the efficiency of all turbines, as well as the cause of the various arrangements of turbine machinery subsequently adopted in different types of vessels. Neglect of this essential ratio and of its influence on the efficiency of the absorption of the kinetic energy in the steam, or else the deliberate acceptance of very low ratios of $\frac{\text{blade-speed}}{\text{steam-speed}}$ has often led to the installation of very inefficient turbine sets, and some of the worst, for instance, the earliest impulse sets fitted in the United States, have had to be removed and replaced by more modern designs. In the case of a single-impulse wheel, a two or three-row velocity wheel, or for reaction blading, the *best* results are obtained with ratios of about 0·47, 0·235, 0·15 and 0·94, respectively. Even in land work these ratios are somewhat sacrificed in order to obtain a slightly smaller turbine and to allow for lower power working than the maximum when the initial pressure is reduced, and in direct-connected marine work, in which it was usually more important to reduce both size and weight than to aim, as in a power station, at maximum economy, these ratios were reduced still further. To-day, when gearing admits of the highest revolutions consistent with the power developed, these ratios have been restored to land practice level, which has in recent years, with increase of pressure, superheat and vacuum, been considerably increased over that of even the last decade.

Calculating Number of Stages Required.

A ready means of calculating the number of stages required is by means of the expression

$K = (\text{mean diameter in inches})^2 \times (\text{r.p.m.})^2 \times \text{No. of rows} \times 10^9$.

The average ratio of blade-speed to steam-speed across a turbine stage or a reaction turbine is given by the expression $\frac{Vt}{Vs} = \sqrt{\frac{K}{2 \cdot 66H}}$ in the case of an impulse, or $= \sqrt{\frac{K}{1 \cdot 33H}}$ for a reaction turbine, where H is the adiabatic heat drop + the reheat factor.

Values of K run from about 80 in H.M.S. *Dreadnought*, at 330 revolutions, to 95 in the *Mauretania*, at 185, and 108 in the *Aquitania*, at 165 revolutions. Channel steamers averaged about 84 to 88, and torpedo-boat destroyers varied from 85 to 95, depending largely on whether the propellers were large or small for their work. With gearing and free choice of turbine revolutions, the K value can be easily increased, and values of K between 160 rising to 175-185, are often employed. In 1910 the highest K in land-station work was about 180; this was subsequently increased to 200-230, and the highest yet installed for very high pressure, superheat and vacuum is about 330. These turbines produce a shaft horse-power for less than 8 lb. of steam, or about half what the *Turbinia* required. The *Lusitania*, with 156 lb. of steam and 28 in. vacuum, and with a K of about 100 at 191 r.p.m., required 12·75 lb. per shaft horse-power. H.M.S. *Hood* requires about 10 lb. per shaft horse-power.

Now, these K values are impossible *on one shaft*. "Compounding," or the use of turbines in series on separate shafts, both passing all the steam, but each only doing half the work, was the method by which efficient subdivision of power was first obtained. When the original single turbine in the *Turbinia* was found to be too powerful for the one screw the arrangement was altered to one consisting of high-pressure, intermediate-pressure and low-pressure turbines on separate shafts, each developing about one-third of the power, and with this alteration a speed of 33 knots was eventually obtained. The patent which covered this arrangement was probably the most important of all those connected with marine work.

Propeller Design.

Although the solution of obtaining adequate turbine efficiency had been found in compounding the solution of propeller dimensions was for some years a matter of difficulty, the continual tendency being to adopt higher revolutions than were advisable. Even as late as 1911, in both torpedo craft and channel steamers, the propeller was often unduly sacrificed in the case of direct-connected sets.

Cavitation was at first a formidable difficulty. Originally circumvented by the adoption of multiple shafts and then of multiple propellers on each shaft, there was still too great a loss of screw efficiency, and this was eventually only overcome by deliberate acceptance of relatively larger sizes and lower revolutions, which, for the same K value, meant accepting larger and heavier turbine machinery. The freedom of choice of propeller revolutions which gearing admits now allows of propellers of perfectly normal proportions being adopted, though in some of the very high-powered destroyers large surface ratios are still retained. At first 0·4 projected surface ratio was used, gradually this was increased to 0·6, and in some very extreme cases of torpedo craft, in which the power developed on trial was unexpectedly much higher than the original screws had been designed before, ratios approaching 0·8 had to be adopted to avoid excessive slip due to cavitation. Whatever theories may be held—there are many—on the reasons for cavitation, there is no disputing the fact that when the thrust-pressure per square inch of projected area exceeds about 13 to 15 lb. per square inch (corrected to 12 in. immersion), then the screw will commence slipping to excess, and if the actual speed of the real slip of the screw (which really measures the velocity of the water flowing to the blades) exceeds 16 to 18 ft. per minute the thrust of the propeller will begin to fall off badly. Tip speed need have nothing to do with cavitation if the blade edges are sharp and the blades thin. The *Viper's*, which reached 12,000 ft. per minute, was deemed excessive; in 1915, in some of the last of the direct-connected destroyers 16,000-17,000 ft. per minute were used with success. It was in the designs for the *Carmania* and *Lusitania* that this influence of propeller performance on the turbine sizes first reached its zenith. It was felt that to use smaller screws than 14 and 16 ft. 6 in. diam., respectively, would be to risk too much, and the reduction in revolutions to 180 which such sizes entailed introduced some remarkable problems in construction.

Structural Design of Turbine.

Some day the construction of steam turbines which developed between 70,000 and 80,000 at 180 r.p.m., will be regarded in the proper light. When the design of "the big Cunarders" was undertaken the biggest low-pressure turbine rotor at work was that in *The Queen*—a 45-in. drum. The largest under construction was the *Victorian's*, of about 93 in. To secure the required K at 180 revolutions these vessels had drums of 96 in. and 140 in., respectively, for high-pressure, and low-pressure, with 123 and 60 rows of blades on each. The longest low-pressure blades were 22 in., giving an overall low-pressure diameter of 15 ft. 4 in. The diameter over the high-pressure blades ran up to 10 ft. That of *The Queen* was barely 40 in.

Quite apart from the cylinder thickness required to withstand the test-pressure—itself a vexed question when first the design

was mooted, as it was held that a blade-strip might result in high-pressure steam filling the whole cylinder—one of the most serious problems that arose was what form and extent would the expansion, when hot, assume. Small turbines were known to meet with frequent trouble from cylinder distortion with their fine clearances: what would a cylinder 10 ft. to 15 ft. in diameter warp to? Would the amount of expansion exceed the permissible blade tip clearances? Then, again, there was the caulking-in of the blades. It was one thing to caulk 50 rows of grooves $\frac{3}{8}$ in. wide by $\frac{1}{4}$ in. deep on 4 ft. diam.; it was quite another when the blades were $\frac{7}{8}$ to $1\frac{1}{4}$ in. with grooves up to nearly an inch in depth. Space prevents further reference to a variety of problems better imagined than described, which occurred when this gigantic step in design was made. We may offer, however, just one contrast between 1907—the year of the launch just 15 years ago—and to-day. H.M.S. *Dreadnought* was the biggest turbine vessel then under steam in the Navy, the *Carmania* in the merchant service. The *Dreadnought's* high-pressure drum was 68 in. in diameter. The new battle cruisers of the "Hood" type, cancelled at the Washington Conference, were to have 160,000 s.h.p., six times the power of the former, double the *Mauretania*. Driven by gearing, their shafts were to run at 210 r.p.m.; the turbines at 1,300. Their low-pressure rotor was also 68 in. in diameter; their low-pressure rotor complete could *almost* (except for the thickness of the Cunarder's drum) have been placed inside the *Mauretania's* high-pressure rotor! As regards the turbine, the introduction of gearing may be said to have eliminated nearly all the structural difficulties connected with turbine construction. The largest turbine rotor ever fitted was the low-pressure exhaust turbine in the *Britannic*. This was 150 in. in diameter and carried 42 rows of blades, varying from 16 in. to $26\frac{1}{2}$ in. in length. The *Aquitania's* low-pressure rotors were 144 in. in diameter and carried 66 rows of blades, varying from 7 in. to 20 in. in length. But whereas the low-pressure blade-speed in these vessels only ran up to about 130 ft. per second, that of the geared turbines of the big battle-cruisers was to be nearly 480 ft. per second. Drum constructions have to be discarded after a speed of about 350 ft. per second is reached, and heavy disc construction used instead. The highest low-pressure blade-speeds used in direct marine turbines seldom exceeded 220 ft. per second in destroyers; in channel steamers it averaged about 150 ft., and in other craft usually less.

Operating Experience.

Besides problems in design and construction there was much to be learnt about the management of turbines under steam. Warming-up, for instance, was an operation requiring considerable care, and the proper supervision of a turbine plant involved no small amount of attention to both boiler and condenser plant. For the one might prime and fill the turbines with water, and the other might leak air and spoil the vacuum, or salt water, which, in time, caused scale to form first in the boiler and then in the high-pressure turbine blading, where it clogged up the blade passages. Distortion of cylinder due to unequal expansion when warming occasionally caused blade-stripping to occur; but a number of other influences have been responsible for this as well. Localised and excessive thrust of steam pipes, lack of freedom for expansion, whipping of rotors, &c., have all borne their share. In some of the early designs the light grooved pistons for the dummy packing used to distort. Later on, special arrangements were introduced so that these rings should not expand away from the packing and so increase the clearances. It may be said that from about 1906-7, when the turbine was firmly established on its merits for efficiency and lightness, attention was devoted more to improving details of design and construction to facilitate operation than to endeavouring to secure greater economy by increasing K values or improving propeller performance, and it was not till about 1910-11 that efforts began to be made in this direction by introducing twin-screw arrangements in cruisers and destroyers and by fitting high-pressure impulse portions in lieu of reaction blading. This latter enabled high-pressure to be utilised even at low power by shutting off nozzles. The quantity of steam which flows through a turbine depends practically solely on the initial pressure within wide limits and for lower power working very low initial pressures were originally necessary. Nozzle type high-pressure ends improved this defect considerably. A very serious defect which once arose was the extraordinarily rapid corrosion of rotor drums on certain services, pieces of metal scale weighing nearly 50 lb. being detached from the interiors! This was traced to faulty operation in not leaving the turbines internally dry, but it was enhanced by the corrosive effect of impure feed water. Another was the rapid erosion of propeller blade roots under certain conditions owing to excessive broken water in front of the screw. This was got over by the use of a harder alloy. Blade stripping has never been as serious in marine work as it has ashore, but the reply to critics of this defect must be that the same form of blading and attachment as was used in the little *Turbinia* in 1897 was also used in H.M.S. *Hood* in 1917. The system has never been altered.

Geared Machinery.

Gearing afloat has entirely superseded direct-connected machinery. In many classes of ships, such as destroyers, light cruisers and channel steamers it has resulted in no saving of weight of turbine installation, but it has greatly improved the economy, thanks to the ability to use a higher K value. In large slow-going vessels it has rendered the adoption of turbine machinery possible. There is now far more horse-power afloat with gearing, partly as a result of war period construction of small high-powered craft, than there ever was of the previous type, and remarkable as it may sound, gearing has been used for quite as many years as direct turbines were until its introduction. It has entirely solved the problem and rendered possible the combination of the propeller of highest efficiency with turbine proportions capable of giving the best thermal efficiency under the conditions of operation.

A Suggested Cause.

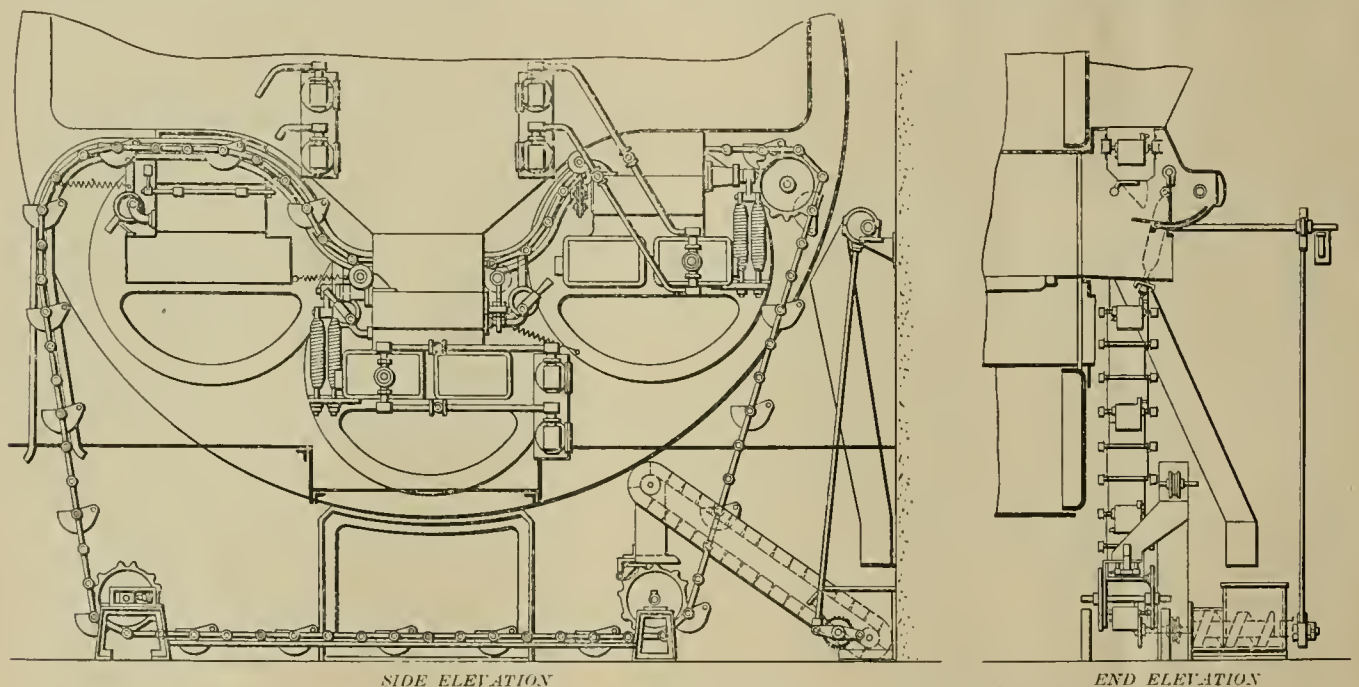
But there is no doubt that a good deal of trouble has recently been experienced with gearing, and more vessels have recently been laid up from this cause than from pure turbine defects. What is the reason? Why should four or five big vessels succumb almost simultaneously at different yards? Why do some ships give trouble and sister vessels not do so? There are a number of causes, but at least one has been widely ignored. The varying intensity of the wake is no novelty at all; its effect on the balancing of engines was discussed at the Institute of Naval Architects in 1901. But the proper balancing and pitching of mercantile propellers is seldom undertaken with the care and precision with which Admiralty propellers are finished, and any defect which may thus arise—it will take the form of torsional oscillation in the shaft due to one blade being even slightly out of pitch or balance—though it would be hardly noticeable in any engine or direct turbine owing to the heavy flywheel effect of the rotor, will immediately react on the pinion teeth through the main wheel. It is true that this does not explain initial wear suddenly ceasing, that is a different matter entirely with a different reason for it; but it goes a long way towards explaining the root cause of one of the most important machinery troubles which have arisen during the otherwise exceptionally satisfactory twenty-one years' experience of the marine steam turbine.

Railroad Acquires a Shipyard.—The New York, New Haven & Hartford Railroad have taken over the Groton Iron Works, Groton, Conn., where a number of steel ships were built and which, during the war, employed 5,000 men. This plant will be equipped for car and locomotive repair work and will employ between 700 and 800 men.

AN AUTOMATIC MECHANICAL STOKER FOR SCOTCH MARINE BOILERS.

Difficulties of Mechanical Stoking at Sea—Timing Arrangement when Cleaning Fires—Sea Trial Results.

The advantages which have followed the use of mechanical stokers on land are too well known to need recapitulation here, and it is only to be expected that these advantages should lead to endeavours to produce similar apparatus for use on board ship. There are, however, many inherent difficulties to be overcome before mechanical stokers can be successfully used in a ship's stokehold, notably the lack of space and the difficulty of charging the hoppers from the ship's bunkers. We published in our June issue particulars of a chain-grate stoker which was being tried for marine work on a Scotch boiler, and we have received a communication on the subject from Mr. Haakon Larsen, of Christiania, describing the Diamond stoker, which he says has overcome the mechanical difficulties which has hitherto prevented the successful application of the principle on sea.



SIDE ELEVATION *END ELEVATION*

General arrangement of Diamond Stoker for Standard Scotch Marine Boiler.

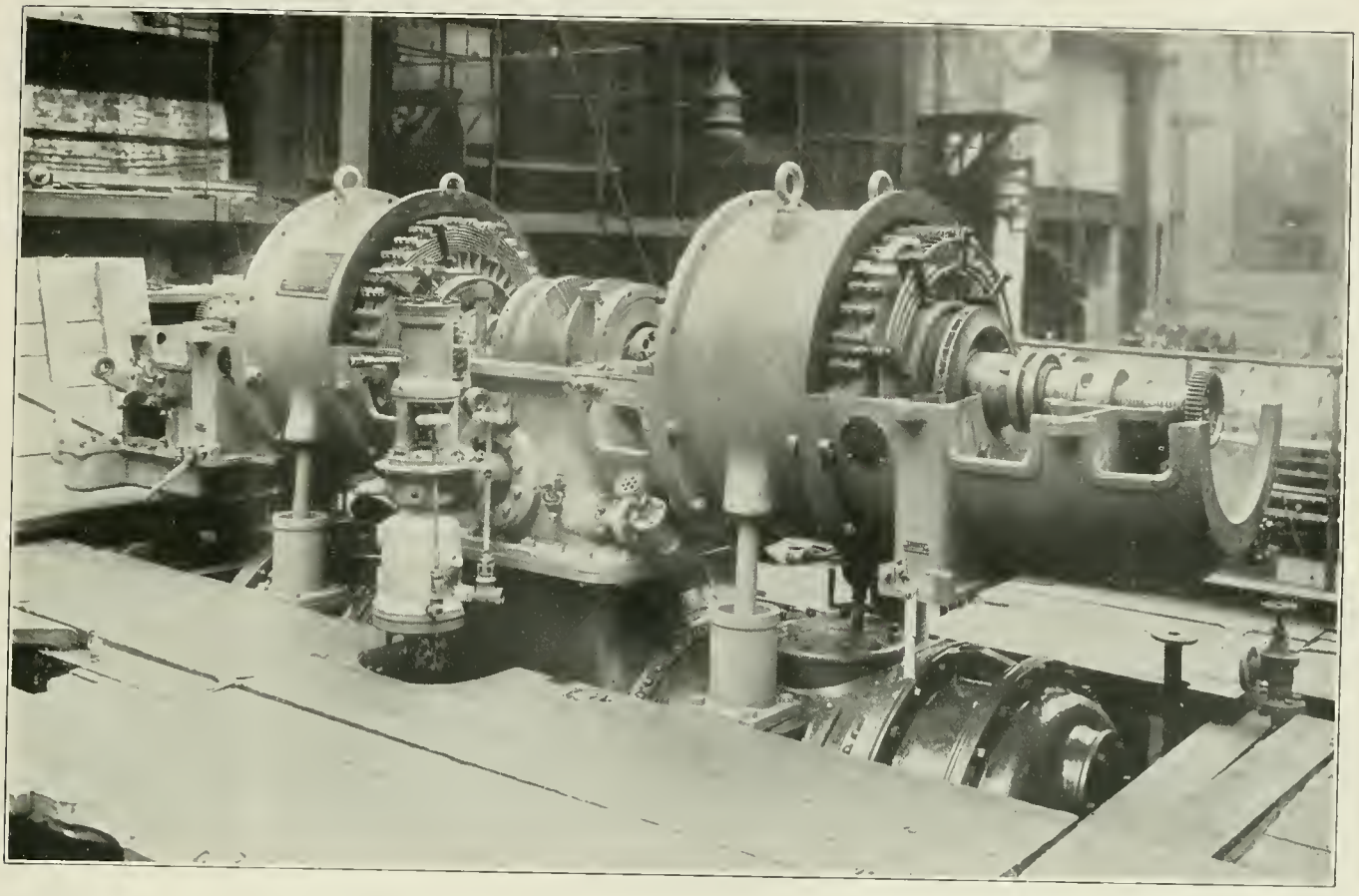
As will be seen from the drawing, the "Diamond Mechanical Stoker" has been designed for fitting to marine boilers of the ordinary cylindrical return-tube type, and it is particularly noticeable that the apparatus takes up but little room, hardly extending above the top of the upper furnaces and projecting only a short distance from the front of the boilers, save at the side of the stokehold where it is attached to the side of the bunker.

A hopper is erected inside the bunker into which the coal is fed and from which it is led to a crusher—shown in the bottom right-hand corner of the front elevation—where the larger pieces are broken up and the small coal is then led to a bucket-filling arrangement whence it is conveyed by an endless chain to small hoppers mounted over the furnace doors. The buckets are provided with a catch-pin which can be placed in one of three different positions, while at the furnace front there is a lever which can be set so as to trip the buckets in accordance with the position of the catch-pin. In this way, under normal running conditions, the catch-pins and the trip levers are so fixed that every third bucket is discharged into each hopper. When, however, the fire in any furnace is being cleaned, the trip lever is placed in a fourth position so that the bucket passes on without being emptied, and since it is desirable to throw coal into the furnace quickly after cleaning, an arrangement is provided for emptying every first and second bucket or all the buckets, into the hopper of this furnace. Further, as a bucket may pass all the furnace without being emptied, a small shoot is provided into which the coal is discharged and from whence it passes again into the bucket-filling arrangement.

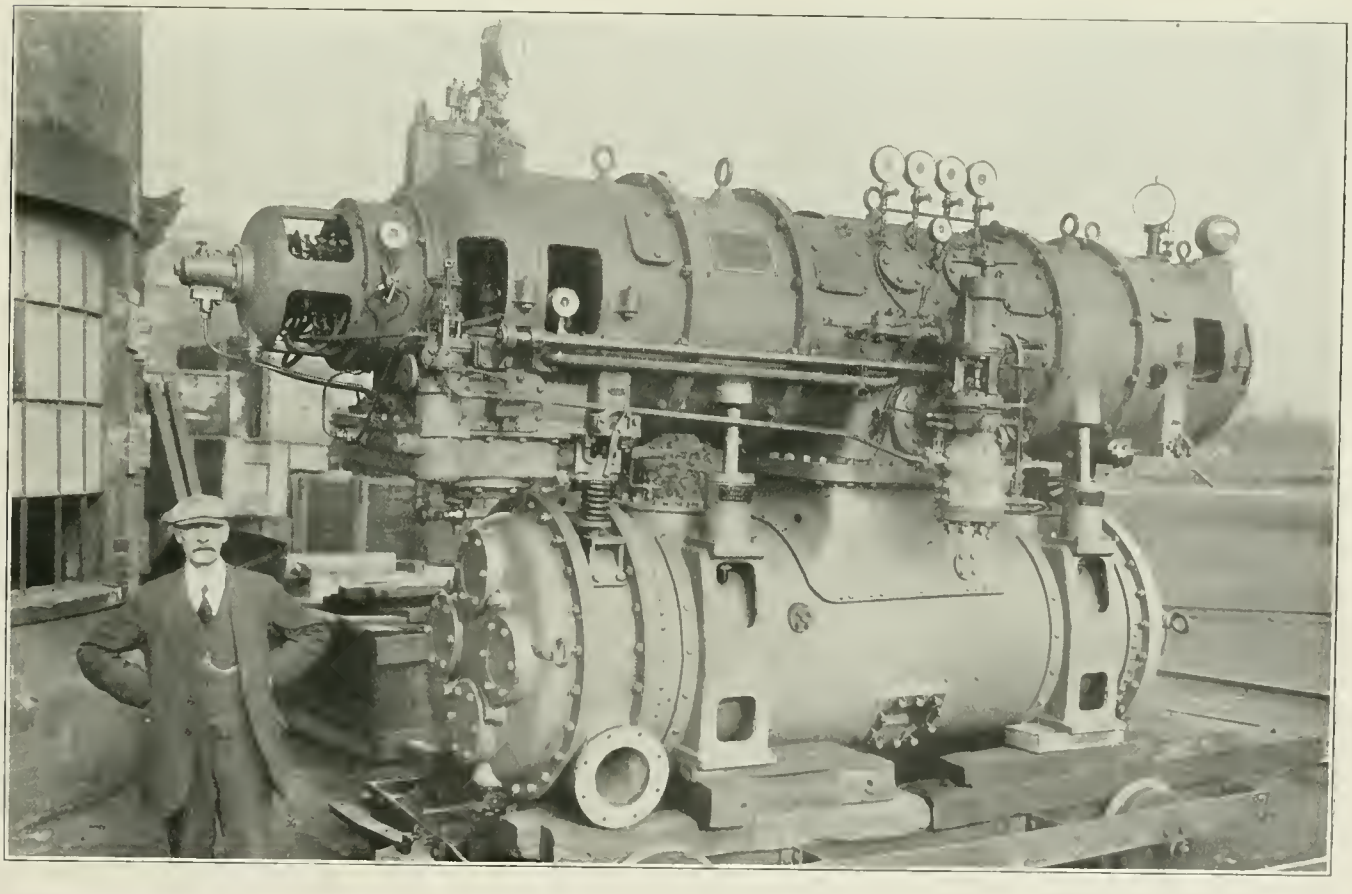
Underneath the hopper on each furnace, as shown in the end elevation, is the automatic shovel which throws the coal on to the furnace bars. The bucket-load of coal drops on to a horizontal plate whence it is projected into the furnace by the vertical plate which is operated by springs. The trap at the bottom of the hopper is closed immediately after each charge of coal has dropped on to the shovel, thus preventing any air from entering the furnace in this way, the necessary supply of air, both over and under the fire, being regulated from the furnace front.

As a result of trials carried out on board ship with an earlier design of stoker of the sprinkler type, it was found that the stokehold staff could be reduced by 50 to 75 per cent., while a saving in coal consumption of 20 to 30 per cent. was attained. As demonstrating the superior combustion which occurs, it may be mentioned that the percentage of CO_2 in the flue gases was 13 per cent. with natural draught and 15 per cent. with forced draught, as against 5 to 10 per cent. with hand-firing.

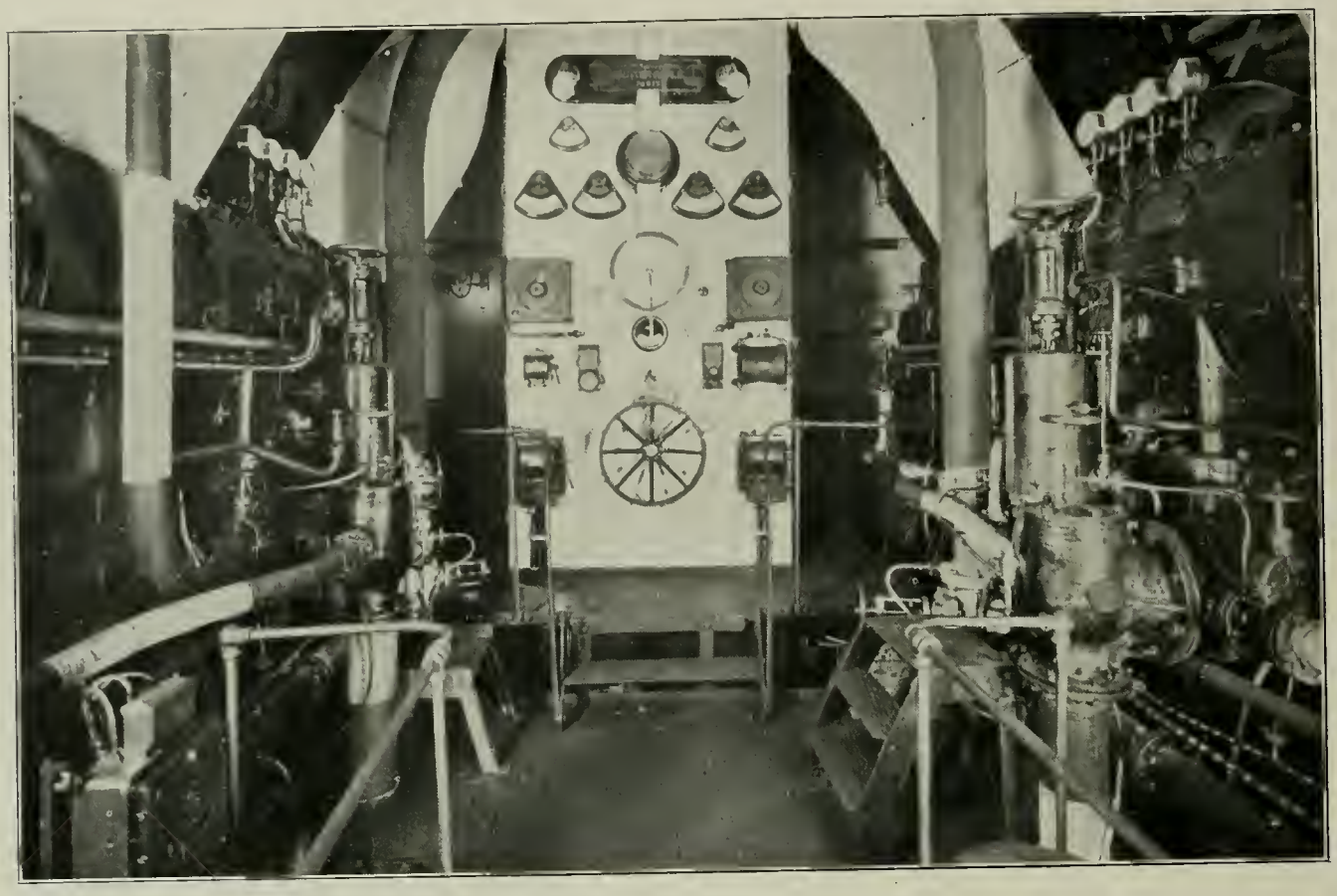
THE PROGRESS OF ELECTRIC SHIP PROPULSION. (*See page* 343.)



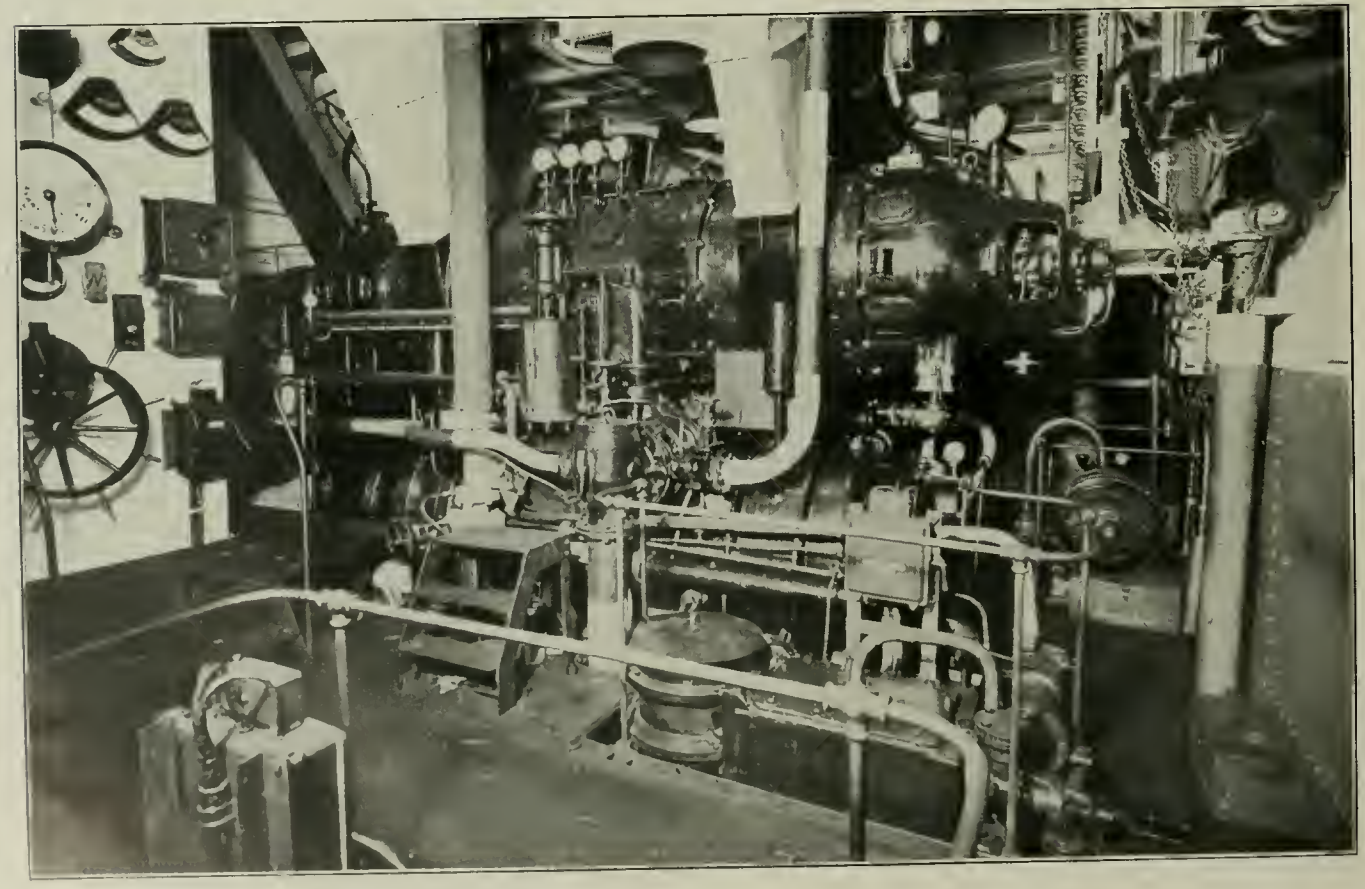
Turbo-Generator for the "Wulsty Castle" in course of construction.



Turbo-Alternator and Condenser for the "Wulsty Castle," constructed by the Brush Electrical Engineering Co. Ltd., Loughborough.



The Engine Room of SS. "Guaruja," showing Main Control Platform at centre with the Ljungström Turbo-Generators on either side.



One of the Ljungström Turbo-Generators. The Main Control Platform is seen on the left. The Air Trunks from the Generators to the Boilers may be noted.

propelling the vessel when the latter is running as a cargo-boat, the other motor running idle.

The second motor, of 2,800 h.p., situated at the aft end of the compartment, has 36 poles and runs at about 163 r.p.m. This serves for propelling the vessel when running as a passenger-boat, the 1,200 h.p. motor being then uncoupled. A single motor might have been used, with two sets of windings corresponding to the numbers of poles required for the two speeds indicated above, but the two-motor arrangement was adopted for the following reasons :—

(1) For each of the two services on which the vessel may be engaged, namely, as a cargo-boat and as a passenger-boat, there is a motor available having the maximum efficiency compatible with its construction.

(2) In the event of one of the two motors breaking down, there is another standing by ready for service.

(3) In view of the importance of the leads connecting the control apparatus with the motors, it was considered expedient to make them as simple as possible.

In the motor compartment there are change-over switches, which are operated with the motors at a standstill, when it is desired to change from one system of working to the other ; that is to say, to take the vessel off the cargo-boat service and put her on the packet-boat service, or *vice versa*. These change-over switches allow of connecting the leads from the control apparatus with one or the other of the two motors. The main electric leads consist of armoured three-wire cables of 200 mm. each, fixed direct to the vessel's bulk-heads by means of metal clamps, the test pressure to which they are subjected at the works being 4,000 volts. The distributing pressure is 1,170 volts, and was determined in such a way as to have only one wire to each slot on the principal motors, an arrangement which ensures simplicity and strength in construction.

Stokehold.

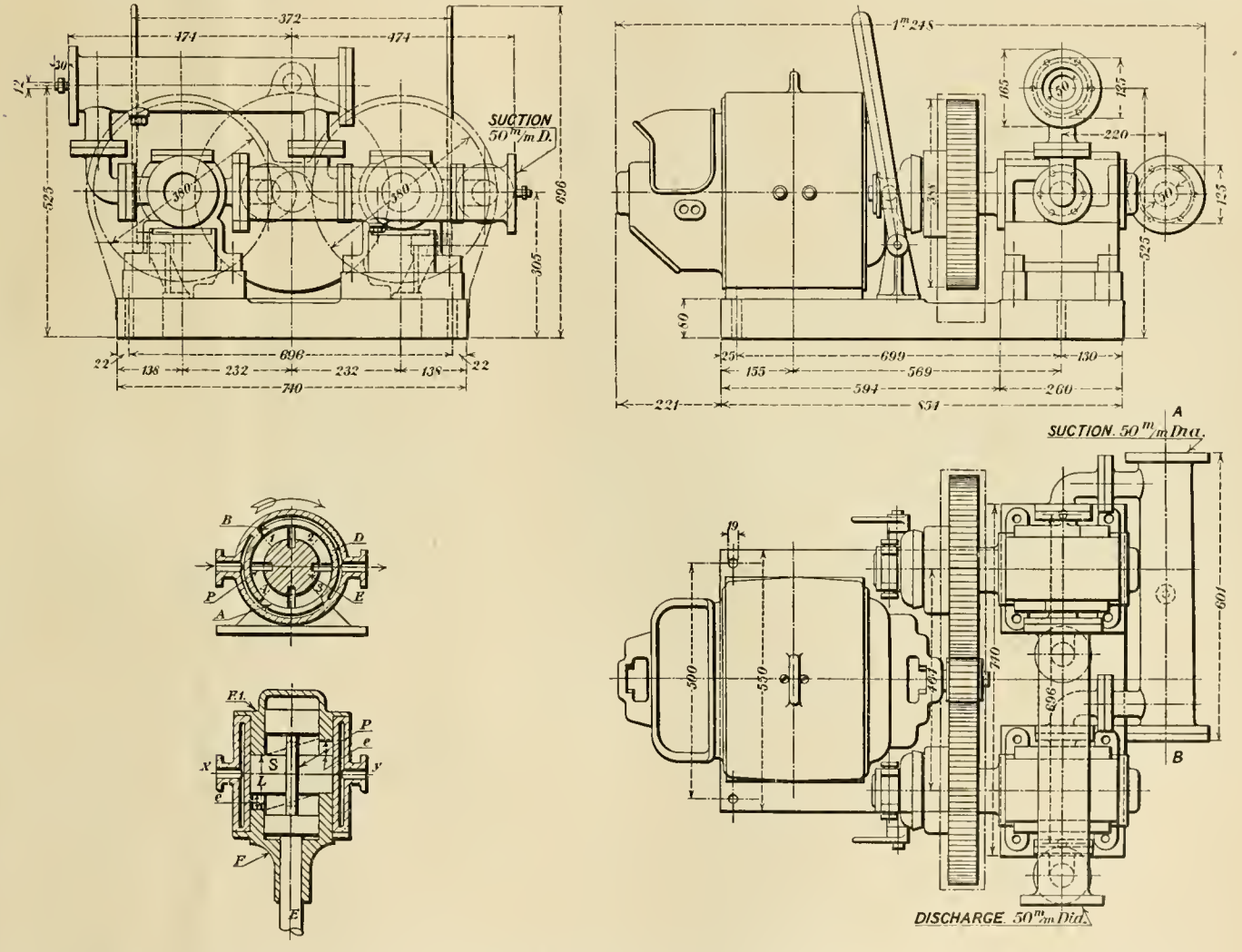
These vessels are equipped for mazout firing. The three boilers are of the Prudhon-Capus type, with accelerated circulation. The boilers are not provided with the fire-boxes of the ordinary cylindrical boilers, but with a built-in firebox containing water-tubes. The advantages claimed for these boilers are the simplicity of their construction and the rapidity with which steam can be raised. The principal dimensions of each of the three boilers are as follows :—

External diameter	4·752m. (15·6 ft.).
Over-all length	3·730 m. (12·2 ft.).
Total heating surface	300 m². (3,225 sq. ft.).
Working pressure	14 kgs. per cm² (200 lbs. per sq. in.)

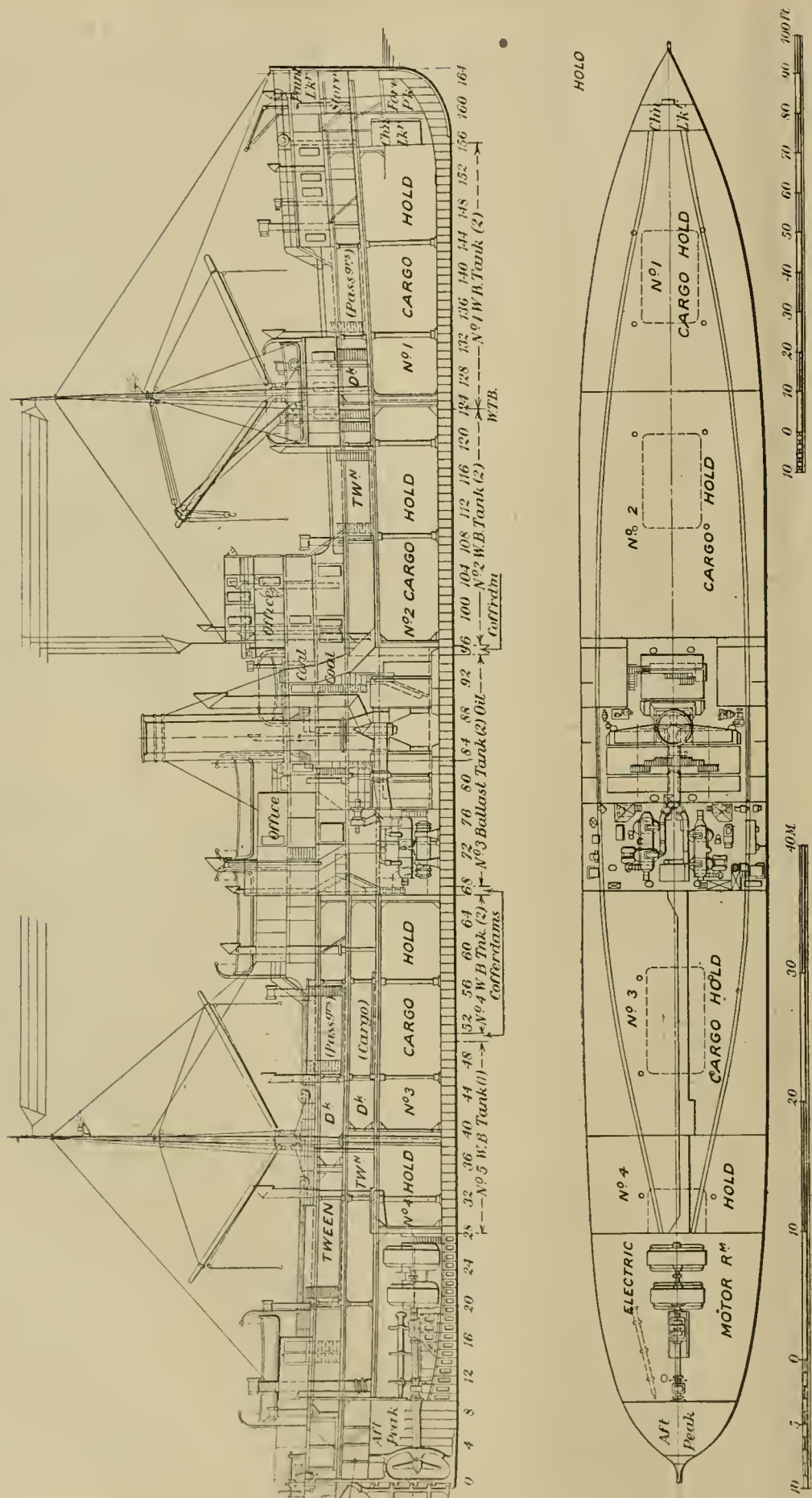
Two of these boilers are sufficient to provide the maximum horse-power of the vessel.

Schmidt superheaters are fitted which allow of raising the steam to a temperature of about 600° Fahr.

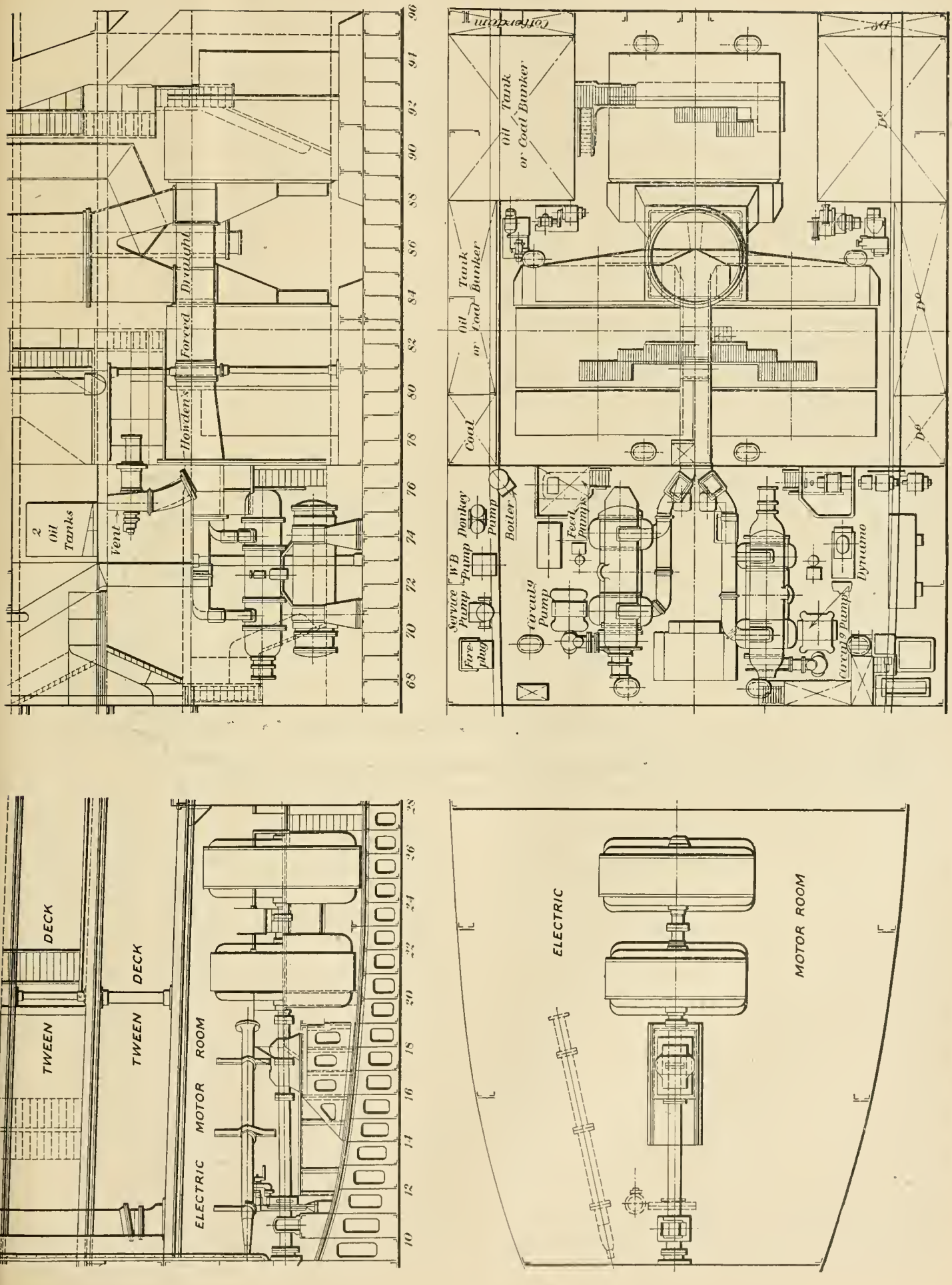
The mazout is carried in four tanks (two on each side of the vessel) and in the two ballast tanks situated below the stokehold and the engine room. The total fuel supply carried



SS. "Guaruja" and "Ipanema," Twin Oil-Fuel Service Pumps of "Rade" Type, driven by Single Electric Motor, with Detail Drawings of Pump.



SS. "Guarujá" and "Ipanema." Electrically-Propelled Cargo and Passenger Steamers, built by the Société des Forges et Chantiers de la Méditerranée for the Société de Transports Maritimes à Vapeur, Marseilles.



General Arrangement of Boiler Room, Main Engine Room and Motor Room on the Electrically-Propelled Vessels "Guaruja" and "Ipanema."

is about 500 tons. The general arrangement drawings of the boiler room, engine room and motor room are reproduced on page 347.

As the vessels are electrically propelled, they have been provided with electrically-driven rotary pumps for the normal mazout firing service. Two single-acting electric pumps of the "Rade" type draw the mazout from the oil or ballast tanks and deliver it to the two elevated settling tanks. One of these settling tanks is in service while the other is being filled. Only a few minutes are required to fill a tank, and as a tank will feed the furnace for about six hours, the mazout, under the action of the slight heating to which it is subjected by steam coils in the stand-by tank, becomes clarified by getting rid of the water which it may contain, as well as various impurities which are subsequently removed by means of a special draining device. The oil thus clarified is drawn from the tank by two double-acting electric pumps of the "Rade" type and delivered to the burners through a heater, which raises it to a temperature in the neighbourhood of 212° Fahr.

The "Rade" pumps for the service of the burner are of special rotary type constructed by Thirion et Cie., and they ensure great regularity in the delivery pressure, which is of special value for mazout firing purposes. Each group of pumps comprises an electric motor, which drives two pumps by means of gearing. One pump only is used for low combustion. The two pumps can be put into circuit when running at any speed. As the electric motor is, moreover, of the 110-volt D.C. type the performance and, in consequence, the delivery pressure can be regulated by varying the speed by means of a field rheostat.

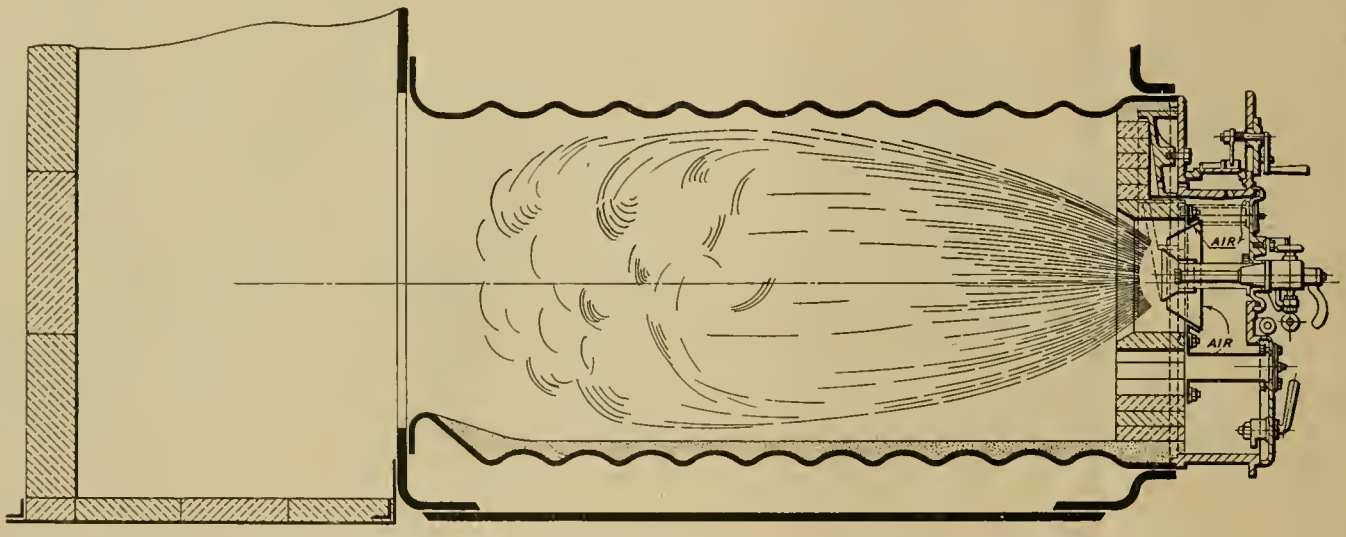
The working principle of these pumps is simple and ingenious. From the drawings of these pumps which we publish on page 345, it will be seen that each has a rotating shaft in which are inserted vanes P to the number of four or more. These vanes can slide lengthwise on the shaft, this sliding motion being guided by helicoidal inclines of the cylinder in the sectors 1 . 2 and 3 . 4. The cylinder is designed in such a way as to have with the shaft, in the sectors 2 . 3 and 4 . 1, opposite bearing surfaces, leaving also opposite free spaces, *e* forming the pump body. The vanes deliver on the motor side in the sector 4 . 1 and draw after them the liquid drawn in by the preceding vane, another vane entering this sector when the preceding one leaves it. The sector 1 . 2 contains the delivery opening, and the sector 4 . 3 the suction on the motor side. Each vane is pushed longitudinally in the sector 1 . 2 by the incline, and re-enters the pump body on the side away from the motor. It is in position in the sector 2 . 3, where it performs the same function as before. As the cycle is repeated on each side with a displacement of 180 deg., the number of vanes in operation ensures a continuous delivery. The delivery openings on the two sides of the pump are, of course, respectively put into communication by ring passages forming part of the cylinder.

The burners are of the type introduced by the Forges et Chantiers de la Méditerranée. They are very simple, easily examined and taken to pieces, and very good atomisers at pressures of from 2 kgs. to 15 kgs., the maximum contemplated for the pumps; that is to say, they allow of considerable variation in delivery, without there being any need to change the burner. The general arrangement of furnace front and burner is shown below. Furnace air for combustion is delivered by two rotary fans and is heated in the air tubes of the ordinary Howden type.

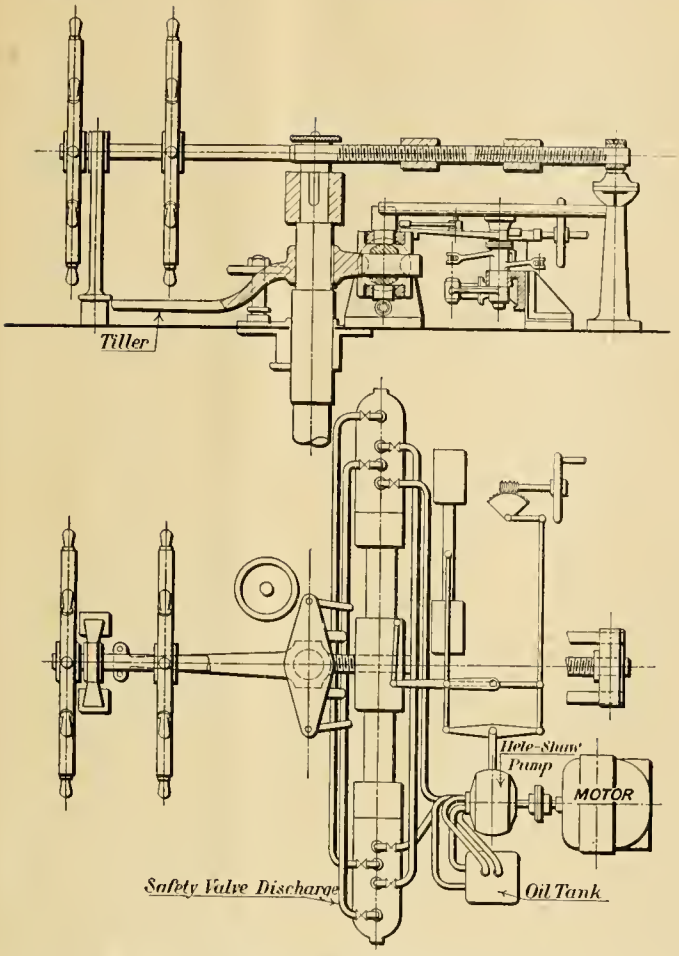
Auxiliary Machinery.

With the exception of the deck winches, an emergency feed pump and an emergency oil pump, which are steam-driven, all auxiliary machinery is operated by 110-volt direct current, in the case of those intended to be worked with the vessel at her moorings, and by 190-volt three-phase current, in the case of those which are only worked when the propelling motor generating sets are working. When the vessel is moored, the direct current is supplied by a steam generating set. When she is at sea, the current is supplied by a rotary transformer consisting of a three-phase motor driving a generator direct. The 110-volt direct current feeds the lighting circuits, the boiler oil pumps, a blower for facilitating the raising of steam, a fresh-water service pump, and an ethyl-chloride refrigerating apparatus. The three-phase current of 190 volts is supplied by two static three-phase transformers of 170 k.v.a., the primary of which is fed direct by the alternators of the generating sets and the power of each of which is sufficient to feed all the three-phase current auxiliary machinery. This machinery may be fed by either of these two static transformers, by means of change-over switches. The 190-volt three-phase current is used to drive the motors operating two circulating pumps, two condensate pumps, two centrifugal feed pumps, two brine pumps serving the main control apparatus, one bilge pump, one service and fire-extinguishing pump, two Howden draught blowers, two rotary transformers, two ventilators in the main motor compartment aft, and one steering gear electric motor.

The steering gear is of the Hele-Shaw electro-hydraulic type, and is illustrated in the drawing on page 349. It consists of



Arrangement of Furnace and Oil-Fuel Burner on the "Guaruja" and "Ipanema."



Hele-Shaw Electro-Hydraulic Steering Gear on the "Guaruja" and "Ipanema."

a constant-duty electric motor driving a variable-delivery Hele-Shaw pump. This pump delivers oil under pressure to one or the other of two cylinders, whose pistons are coupled with the rudder tiller. Control is exercised by varying the stroke of the pump either from aft, by means of a mechanical transmission, or from the bridge by means of a Mactaggart telemotor.

The apparatus is geared in such a way that, whatever may be the position in which the control wheel is placed, the press pistons work the rudder until it is brought into the position corresponding to that of the control wheel, bringing at the same time the stroke of the pump to zero. The electric motor then continues running with the pump running also, but without delivery, until the next control movement.

As an emergency equipment for use in case of breakdown there is provided a wheel and double-screw control gear and a hand tiller.

Official Trials.

The official trials for each vessel consisted of a 24-hour run under cargo-boat conditions, and a 6-hour run under passenger-boat conditions.

During the course of these trials, which were regarded as highly successful, the following figures were recorded :—

Consumption Trial.
(Duration, 24 hours.)

Speed	10·55 knots
Number of revolutions	124
Power on shaft	1,150 h.p.
Mazout consumption per hour	550 kgs.

(The contract provided for an hourly consumption of 750 kgs.)

Speed Trial.

Speed attained	13·2 knots
Number of revolutions	163
Power on shaft	2,700 h.p.

The consumption trial was carried out with a set of Ljungström turbines, delivering into the forward 1,200 h.p. motor, the 2,800 h.p. one being run idle.

The speed trial was carried out with the two sets of Ljungström turbines coupled in parallel and delivering into the aft motor, the forward motor being uncoupled.

On page 317 of our August number we discussed some general features of the turbo-electric propelling machinery on the *Wulsty Castle*, and on page 341 of this issue we publish photographs illustrating sections of that vessel's machinery equipment. That machinery consists of two turbo-alternators of the standard Ljungström type, and in virtue of its compact design this type of turbine has enjoyed a considerable measure of adoption in the earlier electrically-propelled vessels. In any merchant ship several important factors are involved in the propelling machinery, and among such factors are weight, space occupied, initial cost, reliability, economy of operation and maintenance. In appraising the true value of any given system of propulsion, such as the reciprocating engine, direct or geared turbine, turbo-electric, Diesel and Diesel-electric, due regard should be had to the particular trade route and the nature of the service to be rendered. That propelling system which best meets the requirements of all or the most important of the factors already outlined may be said to be the best drive for any given service.

Operating Considerations.

The weight of any type of propelling machinery is subject, to a considerable extent, to the influences of design and arrangement. On the basis of space occupied, the straight Diesel and the Diesel-electric systems, by the elimination of boiler spaces and the reduction of water and fuel tanks, have some advantage over other systems. By mounting the turbines over the condensers in turbo-electric ships, such as the *Wulsty Castle*, considerable floor-space is saved, but, in general, the geared-turbine equipment is more compact than the turbo-electric. It is a matter of difficulty at the present stage in the development of electric propulsion, whether turbo-electric or Diesel-electric, to discuss authoritatively the question of relative initial cost. Electric propelling machinery, in view of the energy conversion, would appear, *prima facie*, to have certain economic disadvantages, yet we have it as the opinion of Mr. W. E. Thau, in a paper recently read before the Society of Naval Architects and Marine Engineers in New York, that the initial costs for the several systems are, in the order : direct Diesel, turbo-electric, geared turbine and Diesel-electric, the last being the cheapest. Mr. Thau explains the paradox in the relative cost of direct Diesel and Diesel-electric equipments by the condition that small Diesel engines and generators can be manufactured ultimately on a mass production basis and stocked, whereas direct Diesel engines and to a great extent both types of turbine drive, in virtue of their size and weight, present of necessity a building proposition. While many may not be disposed to agree with Mr. Thau, it cannot be gainsaid that the Diesel-electric drive has a substantial following, and the performance of the three United Fruit Company vessels now building at Birkenhead will be followed with the closest interest.

From the operating point of view it is claimed by advocates of electric propulsion that a reduction in personnel is effected. Discussing this aspect, Mr. Thau gives comparative engine-room personnel for a given ship as follows :—Direct Diesel, 14 men ; turbo-electric, 14 men ; geared turbine, 13 men ; reciprocating engine, 13 men ; and Diesel-electric, 11 men. These figures are based on oil-fired ships and may be taken as fairly representative. Whatever the actual economy in operating personnel in favour of the combined electric drive may be, opinion favours the view that such economies are likely to be more marked in larger electrically-propelled ships than we have yet seen. In point of reliability and maintenance, the many years' experience gained with large shore generating stations and the highly successful results obtained lead to the view that, given sound manufacture and care in operation, marine electrical equipment in these two respects should be favourably comparable with existing systems of ship propulsion.

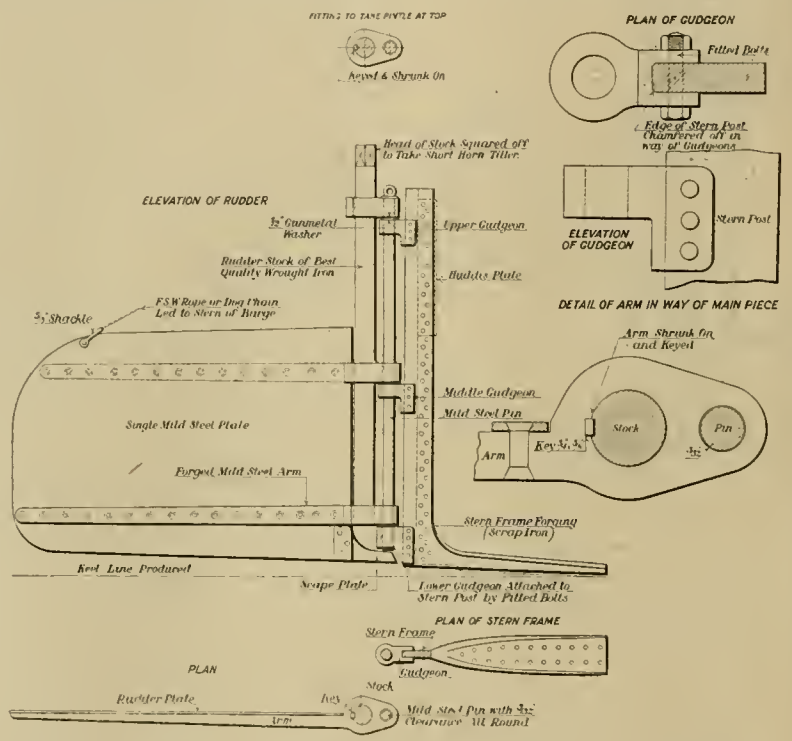
DUMB BARGE RUDDER DESIGN.

Influence of Canal Service on Rudder Design—Structural Considerations—Estimation of Torsional and Bending Forces acting on Rudder Fittings.

In reviewing recent progress in detail design of the type of small craft which navigate our estuaries, rivers and canals, we find that the rudder, particularly in the case of canal craft, which has hitherto been constructed of oak, elm, or on composite lines, is gradually but surely being replaced by the steel rudder of the single-plate type with forged arms, stock, pin, gudgeons, &c.

In view of this, we have elucidated hereunder for the benefit of the average builder of small craft, who is probably unacquainted with the problems associated with steel-plate rudder design, the various processes which might with advantage be followed if satisfactory results are to be obtained.

Considering canal craft, there appears to be considerable divergence of opinion regarding the shape which the rudder should assume in order that efficient manœuvring qualities may be procured. A large number of designers favour placing as much area as possible in the vicinity of the keel line produced and eliminating that at the water level in order to secure ease of control with a reasonable length of tiller. This arrangement results from the common misconception that the maximum stream line velocity occurs in the vicinity of the barge bottom, which, however, is only correct where there is an ample depth of water between the bottom of the barge and the bed of the waterway.



General Arrangement of Single Plate Steel Rudder for Canal Barge.

In canals, where the maximum depth of water is invariably little more than the loaded draught of the craft which navigate them, the bottom drag (which varies with the speed and consistency of the bed) counteracts the velocity of the lower stream lines and renders the effect of any rudder area in their vicinity of very little value as far as manœuvring is concerned.

For all practical considerations, the maximum velocity of stream line may be safely assumed to occur at a level approximating to one-third the draught aft. The surface water also has an appreciable velocity, and it is, therefore, only reasonable that the top edge of the rudder should be arranged to operate in the upper layers. The snapping away of this edge and rounding of the after corner is necessary to allow the rudder to house snugly under the counter of the barge whilst passing through locks, and it will be noticed from the drawing above that a dog chain is shackled through the after-end of the rudder plate to enable the bargee to haul the rudder under the counter after the tiller has been unshipped.

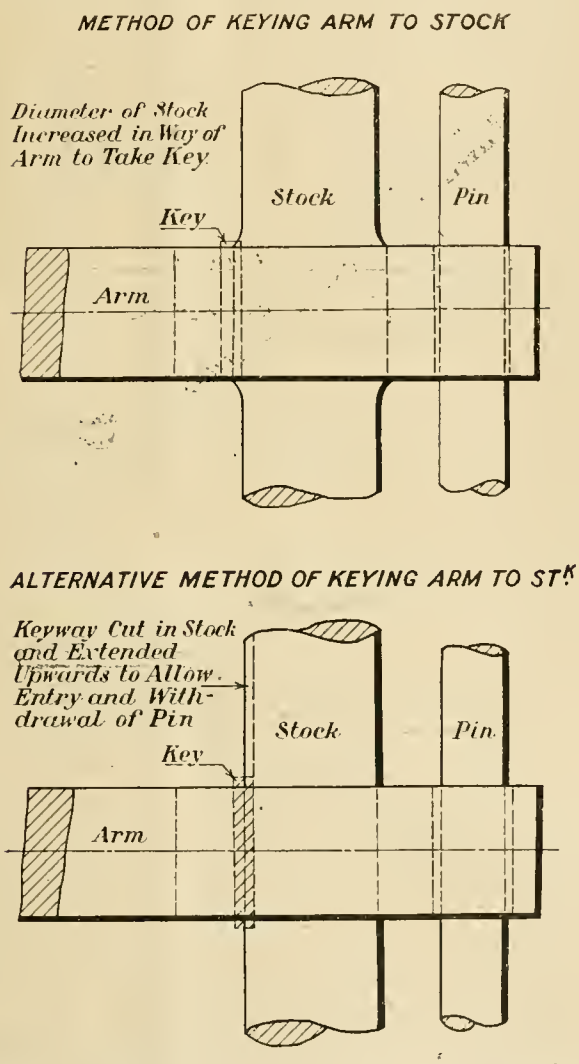
The after-length of keel plate, also that portion of the stern frame connected thereto, usually have an inclination approximating to 1 in. to the foot over a length ranging from 4 to 6 ft., to prevent the stern frame and rudder post straining should the barge ground on a hard bottom. By arranging the lower edge of the rudder plate to be a continuation of this inclined keel line, the major portion of the ineffective rudder area is eliminated and the rudder is well clear of any obstructions in the canal bottom. To prevent ropes fouling under the rudder stock, it is a common practice to fit a scape plate to extend from the underside of the stern frame to cover the gap. A cheaper and equally efficient method, however, is to rivet a piece of plate to the lower forward corner of the rudder plate as shown.

The most reliable method of determining rudder area suitable for any particular craft is by comparison with those which have given satisfactory results under actual service conditions. This comparison should be based on the proportion of immersed rudder area to the immersed middle-line plane of the barge for both the light and loaded conditions. As averages $\frac{1}{1\cdot5}$ and $\frac{1}{1\cdot2}$ respectively are sound ratios to estimate from, but it must be borne in mind that these only apply to small dumb canal craft up to 150 tons displacement. Beyond this, the proportion increases and must be dealt with according to the category in which it falls. It may be mentioned here that for single-screw self-propelled craft of identical form and dimensions to that referred to above the proportion decreases from $\frac{1}{1\cdot2}$ to about $\frac{1}{1\cdot5}$ in virtue of the enhanced velocity imparted to the stream lines which are thrown upon the rudder by the propeller.

The drawing on this page shows the general arrangement of a steel-plate rudder as applied to canal barges of ship-shape form. The plate is of one-piece mild steel supported by two forged steel arms adequately riveted thereto by mild-steel rivets spaced $4\frac{1}{2}$ diameters apart, centre to centre, with countersunk heads and points, the points being on the plate side and finished off flush. The rudder stock is of best quality wrought iron, and keyways are cut in way of the arms to enable them to be keyed after being shrunk on the stock.

To facilitate keying, the stock may be increased in diameter in way of the arms, or, as an alternative, the stock may be left of uniform diameter throughout, the keyway being cut and extended upwards, to permit entry and withdrawal of the

key. Both of these methods are illustrated below. The former method is obviously the stronger of the two, as no weakening of the stock results. For hinging the rudder to the sternpost gudgeons, a long portable mild steel pin is employed, having an eye and flange at the upper end bearing on a forged collar which is shrunk on and keyed to the stock. A minimum clearance of $\frac{3}{32}$ in. should be allowed all round the pin to eliminate, as far as practicable, the possibility of distorting and jamming the pin by blows borne by the rudder. In order to minimise the frictional resistance to turning, the upper gudgeon alone is arranged to take the weight of the rudder, and is accomplished by inserting a gunmetal washer usually about $\frac{1}{2}$-in. thick, between the upper gudgeon and stock collar.



Alternative Methods of Attaching Rudder Arm to Stock.

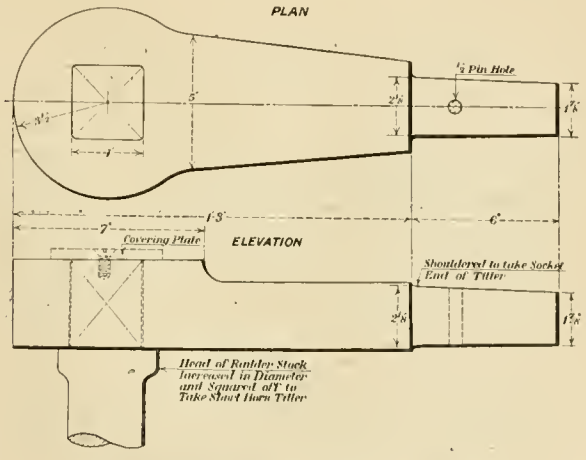
The upper end of the stock is squared off to receive the short-horn tiller, details of which are given in the drawing shown in the next column. It will be found advantageous to keep the top of the stock as low as possible, especially in the case of barges which navigate our main estuaries where swim barges towed up short behind have a tendency to punch the top of the stock with the underside of swim. A suitable material for the tiller is $2\frac{1}{2}$-in. diam. gas tubing, with forged box end for housing the short-horn tiller as illustrated. A teak-wood knob should be fitted into the tube at the handling end. Tillers should always have a chain attachment to an eye-plate riveted to the deck near the sternpost to prevent it being lost overboard whilst passing through locks when it is usually unshipped. On waterways where the barge service is severe, it will prove an economy to have the gudgeons of forged scrap iron attached to the sternpost by fitted bolts. This arrangement ensures ease of removal, fairing, or repairing and replacing in the event of damage. It is also a much cheaper construction as compared with gudgeons forged solid with the stern frame.

Extended experience in the construction and maintenance of barges on our leading waterways for many years, has shown that the cost of repairs to wooden and composite rudders is an item of considerable importance. Extensive damage is frequently caused through grounding, also by other craft being towed astern. Braces, tie bolts, rudder head, gudgeons and pins, &c., require continual overhaul and repair if they are to be maintained in good working order.

Several years' experience with steel-plate rudders, however, has proved them to be both reliable, less susceptible to damage, and consequently less costly in upkeep. They are also lighter in construction and the ease with which they are handled is a point which commends them to the bargee.

Rudder Design.

The determination of the normal pressure on the rudder exerted by the water at various speeds and angles of helm,


PLAN
½ Pin Hole
ELEVATION
Covering Plate
Shouldered to take Socket End of Tiller
Head of Rudder Stock Increased in Diameter and Squared off to Take Short Horn Tiller

Tiller Attachment to Rudder Stock.

also the point of application of the resultant pressure has been investigated both mathematically and experimentally. The former method, especially in connection with rudders for shallow-draught craft, makes no allowance for the reduction in pressure resulting from the dead and eddying water which congregates in the vicinity of the sternpost and rudder base due to both bottom drag and form inefficiency. As neglect in this respect errs on the side of safety however, there is no reason why this method should not be adopted. Actual experiment under conditions similar to those experienced on the service contemplated is the only reliable source of information.

A simple and very suitable empirical formula for pressure is that introduced by Colonel Beaufoy, who, in 1790, deduced from experiment that the normal pressure " P " could be adequately represented in terms of rudder area, the square of the speed of the water flowing past the rudder and angle of helm. His well-known formula, namely :—

$$P = 1{\cdot}12\, A v^2 \sin \theta \quad . \quad . \quad . \quad . \quad (A)$$

gives very good results over a wide range of conditions of service, and can be safely employed in the case of canal craft. In applying this formula,

A = area of rudder in square feet ;
v = speed in feet per second ;
θ = maximum angle of helm, say, 40° ;
P = the normal pressure in lbs.

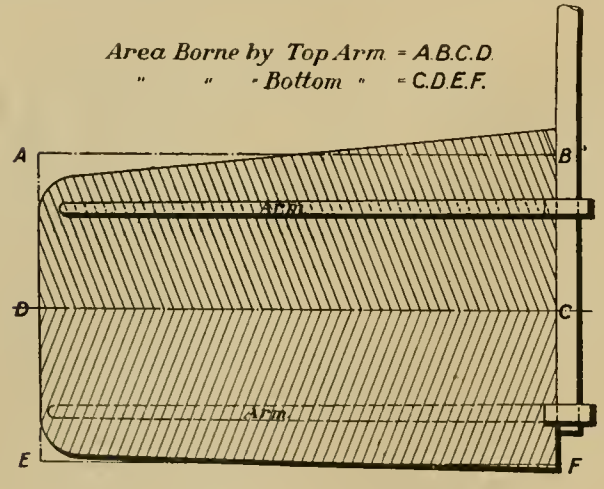
In determining v, the due allowance must be made for the frictional wake. A good average allowance for this is 6 per cent. off the speed of the barge.

The formula generally adopted for determining the distance of the centre of pressure from the leading edge of the rudder is that proposed by Joessel, who concluded from the results of experiment that this distance D for rudders actuating in *deep* water, is adequately represented by

$$D = (0{\cdot}195 + 0{\cdot}305 \sin \theta)\, b \quad . \quad . \quad (B)$$

where b represents the breadth of rudder in feet, θ the maximum angle of helm, and D the distance of the C.P. abaft the leading edge. Strictly speaking, a portion of the stock should be included in the rudder area as it undoubtedly contributes to the turning effect on the vessel. In practice, however, this is ignored. The use of this formula is not recommended in the case of canal barges, where the centre of pressure is found to be further aft than that given by formula B. A more accurate result is obtained by assuming the resultant pressure to act at the centre of gravity of the rudder area.

For shallow-draught craft where the spans between the gudgeons are so small as to render the strains introduced by bending practically negligible, the estimation of the diameter of rudder stock results in a straightforward investigation of the



Distribution of Area borne by each Rudder Arm.

torsional stresses only. Assuming the maximum angle of helm to be 40°, the corresponding twisting moment to which the stock will be subjected is given by the product of the normal pressure P and the distance of the centre of pressure (*i.e.*, the centre of gravity of rudder area) abaft the centre line of stock.

$$\text{i.e., T.M.} = P \times D \text{ ft. lbs.}$$
$$= 1{\cdot}12\, Av^2 \sin 40^\circ \times D \text{ ft. lbs.} \quad . \quad . \quad . \quad (P).$$

The twisting moment is also represented in terms of stock diameter by

$$\text{T.M.} = \frac{\pi}{16}\, q\, d^3. \quad . \quad . \quad . \quad . \quad (Q).$$

Where $\pi = 3{\cdot}1416$, q is the maximum torsional stress permissible for the material of which the stock is composed, and d represents the diameter of the stock in inches.

For wrought iron, q should not exceed 4 tons per square inch, and in the case of cast steel, 5 tons per square inch.

By equating equations P and Q, the value of d is at once determined. Thus—

$$\frac{\pi}{16}\, q.d^3. = \frac{1{\cdot}12\, Av^2 \sin 40^\circ \times D \times 12 \text{ inch tons}}{2240}$$

$$d = \sqrt[3]{{\cdot}0049\, Av^2 D} \text{ for wrought iron.}$$

Diameter of Pin.

The shearing force on the pin in way of any particular gudgeon is assumed equivalent to the total pressure p borne by that portion of the rudder plate which is carried by the corresponding arm. The areas allotted to the rudder arms are shown diagrammatically in the previous column.

To secure a satisfactory pin the maximum pressure p borne by any arm should not exceed its sectional area, multiplied by the working shearing stress. Thus—

$$p \text{ lbs.} = \frac{\pi}{4}\, d^2 \times f_s$$

where p is the pressure in tons and f_s the maximum shearing stress in tons per square inch allowed for the material of which the pin is made. For mild steel $f_s = 4{\cdot}5$ tons per square inch, and d = diameter of pin in inches.

Thus (for mild steel)—

$$d = \sqrt[3]{0{\cdot}3}\, p \text{ inches.}$$

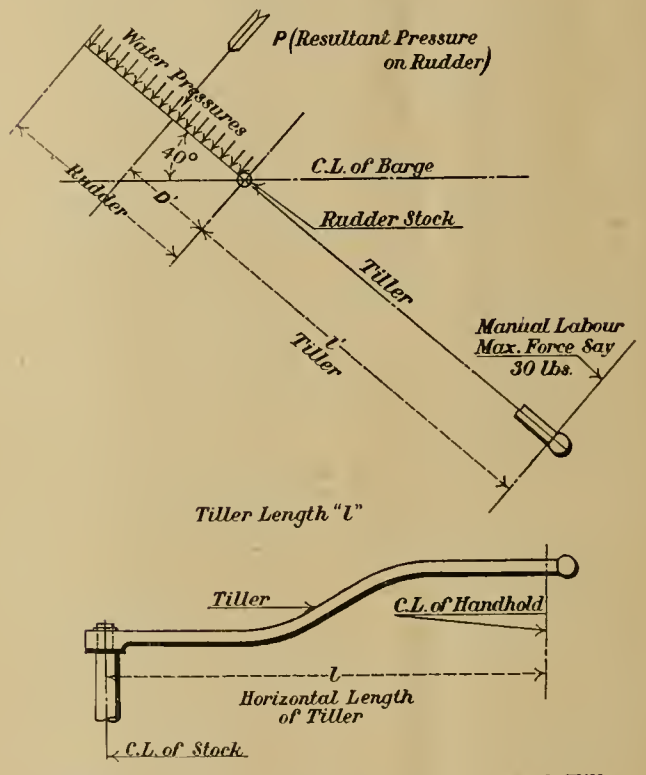


Diagram of Forces acting on Rudder Plate and Tiller.

Length of Tiller.

Ease of rudder manipulation is a point which should be thoroughly investigated on all craft, as neglect in this respect often results in a difficult craft to handle with the usual long list of damages in its wake. With the rudder at its maximum angle of helm, the pull on the tiller end should not exceed 30 lb., providing there is sufficient deck space for handling a tiller of corresponding length. The estimation of tiller length results in a simple problem of moments as shown diagrammatically above.

Referring to equation P, it will be noted that the twisting moment which has to be overcome to rotate the rudder equals

$$\text{T.M.} = P \times D \text{ ft. lbs.}$$
$$= 1{\cdot}12\, Av^2 \sin 40^\circ \times D \text{ ft. lbs.}$$

For equilibrium, the moment of manual labour must equal the moment of water pressure on the rudder.

That is to say—

$$30 \text{ lb.} \times l \text{ ft.} = 1{\cdot}12\, Av^2 \sin 40^\circ \times D$$
$$l = \frac{1{\cdot}12\, Av^2\ 0{\cdot}643 \times D}{30}$$
$$l = 0{\cdot}024\, Av^2\, D \text{ ft.}$$

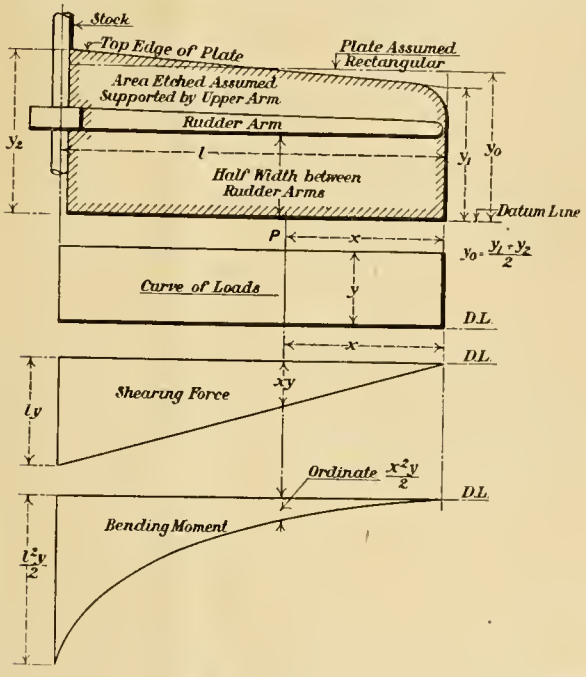
Where l represents the horizontal length of tiller from the centre of rudder stock to the centre of hand hold.

Rudder Plate and Arms.

The thickness of the rudder plate is chiefly settled by practical considerations of wear and tear, rather than by mathematical calculation, and mild steel plates varying in thickness from $\frac{1}{2}$ in. to $\frac{11}{16}$ in., should prove adequate for the type of rudder under consideration.

In determining the scantlings of the arms, each arm is assumed to support an area of plate as shown etched on the previous page. For all practical purposes, however, and also for simplicity, this area may be taken as being purely rectangular and of mean depth equal to $\frac{y_1 + y_2}{2} = y_o$, say, as represented by the dotted lines.

The scantlings of any arm may be reduced as its after extremity is approached in view of the corresponding reduction in bending moment, to which it is subjected, as shown



Bending Moment, Shearing Force and Load Diagrams.

by the diagram above. Very little mathematical knowledge is required in determining the bending moment and associated stress if the following semi-graphical method is employed and the several points borne in mind.

(1) The shearing force at any point along the arm is equal to the area of the curve of loads (*i.e.*, of water pressure) borne by the portion of the plate abaft that point.

(2) The bending moment at any point along the arm is equal to the area enclosed by the curve of shearing forces abaft that point.

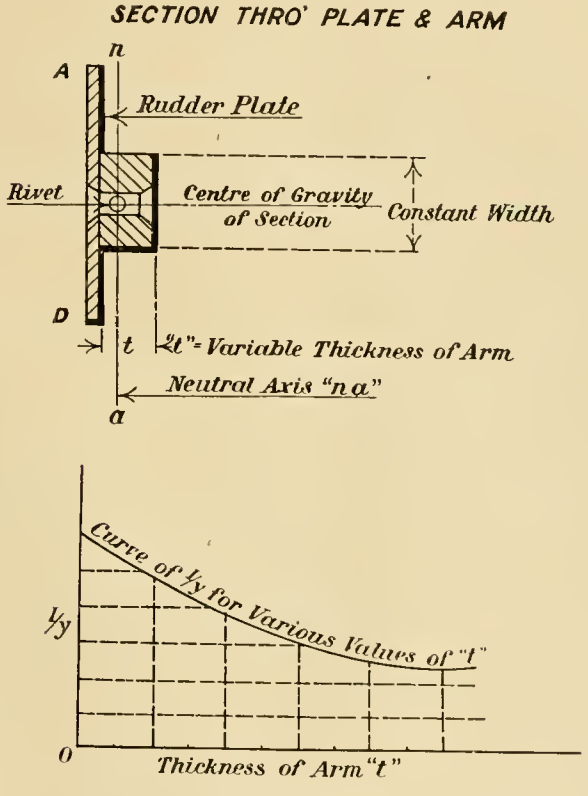
Working on the foregoing assumption that the plate area borne by the arm is rectangular and of mean depth y_o, the curve of loads will be a straight line running parallel to the datum line. Any slight error which may be introduced on this account will err on the side of safety and may therefore be ignored.

The curve of shearing force is now determined from the curve of loads as described in (1), and is obviously a straight line, the ordinates of which range from zero at the after-end to a maximum at the stock, the value of which is equal to the total area of the curve of loads, namely, $l \times y$.

The bending moment at any point P, distant x feet from the after end of arm, is equal to the area of the shearing force curve beyond that point in accordance with (2), and equals $\frac{x \times xy}{2} = \frac{x^2y}{2}$. By plotting these ordinates a fair parabolic curve should be obtained.

Having determined the bending moment, the stress to which the material is subjected can now be investigated. It is not considered necessary to deduce the well-known formula $I = \frac{M\,y}{f}$, as this can be found fully described in any standard text-book on applied mechanics. It is sufficient here to state that for any material subject to bending strains, the relationship $\frac{I}{y} = \frac{M}{f}$ holds good where :—

f = the maximum working stress allowed in the material, due allowance having been made for the usual factor of safety.



Thickness of Arm for Estimated Values of $\frac{I}{y}$

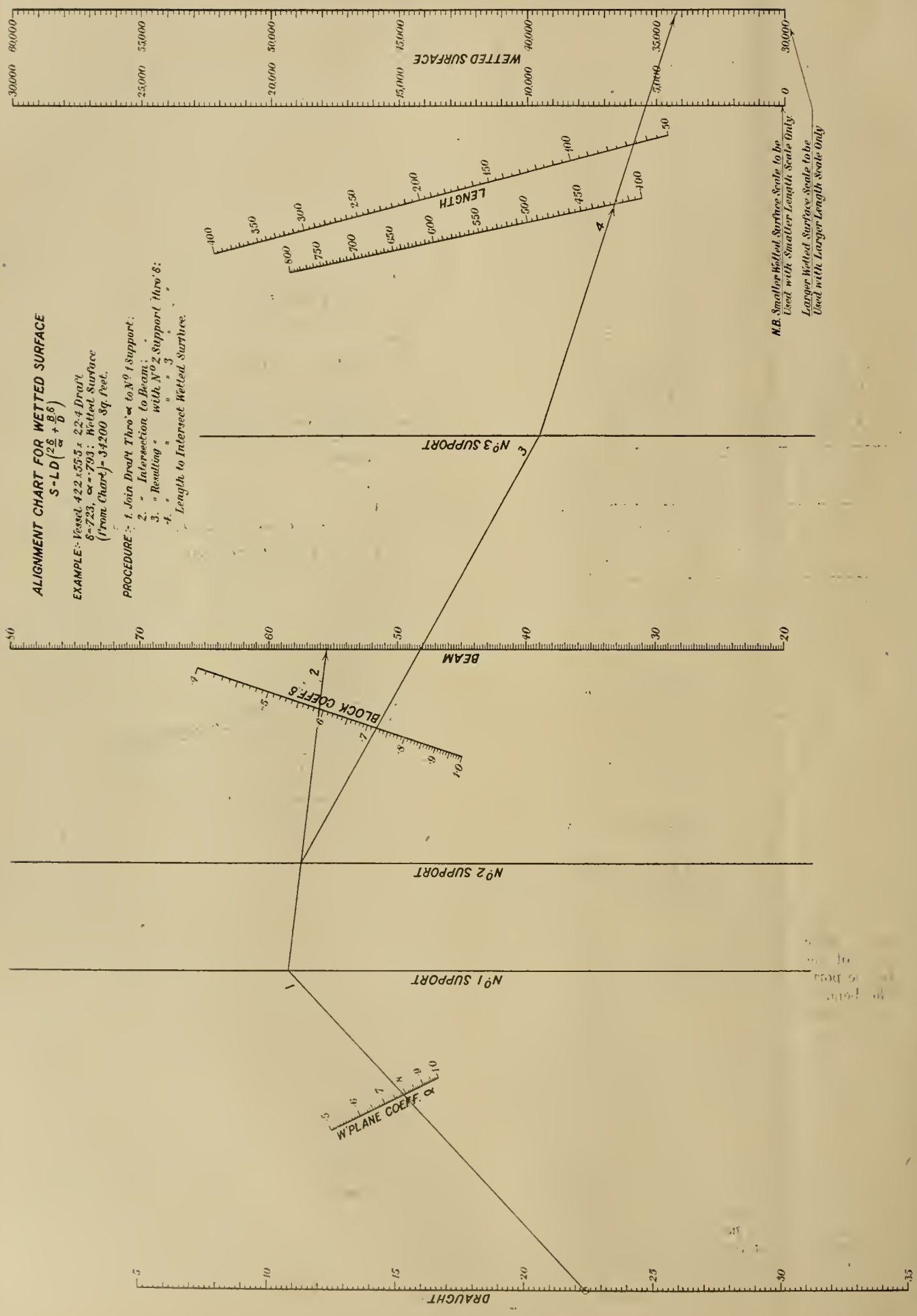
For mild steel, the value of f may be taken at 4·5 tons per square inch.

I = the moment of inertia of the arm and rudder plate at the section selected. It must be borne in mind that this section should always be taken through a rivet hole and the inertia calculated about an axis passing through the centre of gravity of the area of the section and running vertically parallel to the rudder plate.

y = the maximum distance of the material in the section from the neutral axis and M = the bending moment at the section selected, as measured from the curve.

Having determined the values of $\frac{I}{y}$ for a number of sections along the arm, the next step should be to prepare a curve giving values of $\frac{I}{y}$ for varying thicknesses of arm, due allowance having been made for the material eliminated by the rivet hole. The width of arm having been decided should remain constant, so as to permit uniform riveting.

It is now a very simple matter to read off from the curve above, the thicknesses of arm corresponding to the estimated values of $\frac{I}{y}$, at the sections selected.


ALIGNMENT CHART FOR WETTED SURFACE
S = LD(2.8 + 3.6/D)
EXAMPLE:- Vessel 422 x 55.5 x 22.4 Draft
δ=.723, α=.793: Wetted Surface
(From Chart) = 34200 Sq. Feet.
PROCEDURE:- 1. Join Draft Thro' α to N° 1 Support.
2. " Intersection to Beam;
3. " Resulting " with N° 2 Support thro' δ:
4. " " " " 3
Length to Intersect Wetted Surface.
WETTED SURFACE
LENGTH
BEAM
BLOCK COEFF. δ
W. PLANE COEFF. α
DRAUGHT
N° 1 SUPPORT
N° 2 SUPPORT
N° 3 SUPPORT
N.B. Smaller Wetted Surface Scale to be Used with Smaller Length Scale Only.
Larger Wetted Surface Scale to be Used with Larger Length Scale Only

Application of Alignment Chart to the Solution of the Formula for Wetted Surface.

THE WETTED SURFACE OF SHIPS.

By E. V. TELFER, M.Sc.

Although the number of approximate formulæ which exist for the rapid calculation of the wetted surface of ships is quite considerable, the number in actual use by designers is probably restricted to three. These three, the Mumford (or Denny), the Taylor and the Admiralty formulæ, are in world-wide use, and are quoted in practically every British and Continental text-book. Of these three, the Mumford formula is perhaps the simplest, and is the one generally used in this country. It will be recalled that this formula was first given by Sir Archibald Denny, in a paper before the Institution of Naval Architects, in 1895. The formula preserved the form of the earlier formula proposed by Dr. Kirk but was set up quite independently from a detailed analysis of the data of a large number of vessels. The formula has proved to be a remarkably reliable approximation and has been found to be applicable to a variety of types. In view of the invariably small

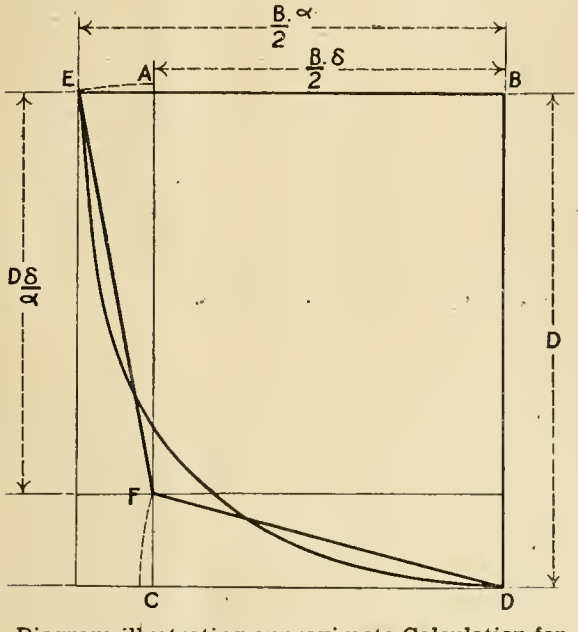


Diagram illustrating approximate Calculation for Wetted Surface.

percentage error of the formula it will be, perhaps, interesting to examine its formation. The most convenient presentation of the formula is—

$$S = LD\left(1{\cdot}7 + \frac{B.\delta}{D}\right)$$

L, B, D, δ being the length, breadth, draught and block coefficient of the vessel respectively. It will be remembered that the Kirk formula is—

$$S = LD\left(2 + \frac{B.\delta}{D}\right)$$

and it is usually stated that the difference in the constants, 1·7 and 2, is reasonably explained by the difference in the fullness of the vessels upon which the formulæ are respectively based. If reference is made to Dr. Kirk's original work, it will be found that the above formula does not conform with the initial assumptions involved in his well-known complementary "Block Model." For, as the original length used referred to the expanded length of the sides of the block model, it was found that the true surface of the block model was largely in excess (*i.e.*, about 8 per cent.) of that of the ship-shaped vessel to which it purported to correspond. Instead of the expanded length on the sides, the length of the vessel between perpendiculars was taken and used in the above formula with an immediate increase in accuracy. There, to the best of the present writer's knowledge, the formula was left. A further consideration of the Kirk formula shows that it really accurately depicts the wetted surface of quite a different complementary block model from that initially used by Kirk. Consider the diagram in the opposite column. Here the underwater portion of the ship is represented by a prismatic solid whose breadth at any draught is given by the beam moulded multiplied by the particular waterplane area coefficient α. If now the mean value of Bα (which is of course Bδ) is drawn in a further complementary solid is obtained. The surface area is easily seen to be given by the Kirk formula, *i.e.*,

$$\begin{aligned} \text{Sides of model} &= 2\,LD \\ \text{Bottom} &= LB\delta \\ \therefore\ \text{Surface} &= LD\left(2 + \frac{B\delta}{D}\right) \end{aligned}$$

The apparent reliability of this complementary solid encourages one to assume that the girth of the original waterplane area coefficient solid would give a very close approximation to the vessel's mean girth. Commencing therefore with this assumption, the waterplane area coefficient curve is replaced by a trapezium enclosing an equal area. This, it will be remembered, is the first step in the deduction of the Morrish formula for the position of the vertical centre of buoyancy. This has been done in the diagram, and it is there seen that the girth of this trapezium will be practically equal to, or most probably is generally slightly in excess of, that of the basis curve. The girth EF and FD of the trapezium can be expressed in terms of B, D, δ and α but after considerable effort no simple and practical expression could be set up. In view of this difficulty a further approximation has to be introduced. This is to assume that as the length EF is but slightly in excess of AF, and the length DF similarly but slightly in excess of DC, the sum of AF + CD will be probably nearer to the true girth of the basis curve than the sum EF+DF. AF is, of course, the Rankine Mean Depth and equals $D\frac{\delta}{\alpha}$, CD, it will be recalled, is the Ramage Mean Waterplane (see I.N.A. 1897) and equals Bδ. The wetted surface of the complementary model, and hence of the ship it represents becomes

$$\begin{aligned} S &= L\left(2D\frac{\delta}{\alpha} + B\delta\right) \\ &= LD\left(2\,\frac{\delta}{\alpha} + \frac{B}{D}\,\delta\right) \end{aligned}$$

If in this latter expression a value of $\frac{\delta}{\alpha}$ of ·85 be taken (which is incidentally a very usual value), the Mumford formula is at once obtained. This fact at once enables a certain degree of confidence to be placed in the more comprehensive formula now deduced. From a general examination of the diagram there is no doubt that the mean girth (on the assumptions made) does decrease with $\frac{\delta}{\alpha}$, and it is probable therefore that the new expression will yield at least as accurate results as the Mumford formula. The introduction of the $\frac{\delta}{\alpha}$ term eliminates the uncertainty which has existed in practice in the choice of the constant below 1·7, and between 1·7 and 2. It also shows that δ alone is not a complete measure of fullness and should not be the criterion for interpolation between 1·7 and 2 as was

generally supposed. It is quite possible to have a high block coefficient and still obtain accurate results with the constant 1·7, provided the value of α is correspondingly high. The new formula explains the reason for the reliability of the Mumford formula, since the range of $\frac{\delta}{\alpha}$ value, usual with passenger and intermediate passenger vessels, is from about ·82 to ·88, of which the value ·85 involved in the Mumford formula is seen to be the mean.

The formula has been applied over a variety of types of $\frac{\delta}{\alpha}$ values, ranging from ·80 to ·96, and uniformly consistent agreement with the correct wetted surface was obtained. For very low values of $\frac{\delta}{\alpha}$, associated with a $\frac{B}{D}$ ratio greater than 2·0, the formula will give low results which is to be expected in view of the basic assumptions of the formula, as is the case with the third example shown in the table in the next column. If the Mumford formula is applied to this example, a positive error of 12½ per cent. is obtained. As such low values of $\frac{\delta}{\alpha}$ are very rarely met with in practice, there is no need to complicate the simplicity of the formula here deduced in order to take into account such extreme cases. This range of accuracy is confirmed by application of the formula to prismatic geometric solids. For a box form and for a cylinder with its axis in the waterline the formula is absolutely correct. On the other hand, for a triangular prism it is quite inapplicable. For the usual run of merchant and passenger ships which are well removed from the case of the triangular prism there is however but little doubt that the formula will yield accurate results.

To complete this article, the formula will be expressed in the form of an alignment chart. To facilitate this the formula requires to be somewhat rearranged. We have

$$S = LD\left(2\frac{\delta}{\alpha} + \frac{B}{D}\delta\right)$$

$$\text{or } S = L\delta\left(\frac{2D}{\alpha} + B\right)$$

which is now the most convenient form for graphical presentation. This is carried out in the usual manner and is shown on page 354. This chart may be used either for feet or metric units. To show the working of the chart the second of the following examples is worked out on it.

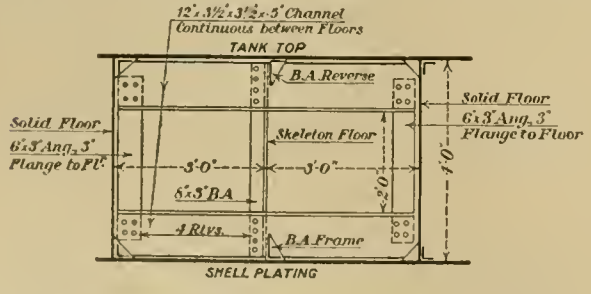
Table showing Accuracy of Formula for Wetted Surface for Different Types of Vessels.

Length.	Beam.	Draught.	Block Coeff. δ.	W'Plane Coeff. α.	$\frac{\delta}{\alpha}$.	Wetted Surface.		Percentage Error.
						Formula.	From Lines.	
586·0	74·5	28·8	·678	·812	·83	57,100	56,800	+·53 %
422·0	55·5	22·4	·723	·793	·912	34,200	34,500	−·86 %
120·0	25·6	9·8	·46	·72	·644	2,940	3,040	−3·3 %

INTERCOSTAL GIRDERS IN DOUBLE BOTTOMS.

In all designs for the internal construction of double bottoms it is essential to provide the requisite strength of structure with the minimum amount of plating.

It is an open question whether the weight of the intercostal girder would be of more value from a strength point of view if it were distributed across the bottom as an increased thickness of shell plating in the way of the double bottom. Apart altogether from structural considerations, intercostal girders are necessary to guard against the dangers arising from the free movement of water when the tanks are not filled. The



Suggested Arrangement of Channels in lieu of Intercostal Plate Girders.

open floor system, with a solid floor on every second or third frame, having solid floors in engine space, under boiler bearers and other machinery, is the form of construction at present most generally adopted. It provides easier access to the tanks than the solid floor on every frame, and also proves satisfactory on service.

The intercostal plate girders divide the tanks into two or three bays between the centre line and margin, according to the number of girders installed. It has been suggested to dispense with these intercostal plate girders, and to fit, in lieu of these, channels top and bottom inside the tank as illustrated in the opposite column. This arrangement provides an easier means of access between the bays in the tank, which would prove beneficial for supervision, would facilitate repairs and reduce upkeep.

The drawing opposite shows a channel fitted top and bottom between solid floors. The girders illustrated are formed of channels, and these can all be cut to the required lengths from solid floor to solid floor before erection. The intermediate bulb angle frame and reverse frame pass through slots cut in the channels, and the vertical struts between solid floors have an efficient riveted connection to top and bottom channel. The channels are connected to the solid floor by an angle which has a single riveted connection to the floor plate and a double riveted connection to top and bottom channel. These vertical angles are hydraulically riveted to the floors before erection. In place of top and bottom channels in vessels of small dimensions bulb angle sections may be adopted, provided the structural strength and riveted connections are equivalent to the requirements for intercostal plate girders.

The open floor system of construction has proved efficient even when heavy concentrated loads are carried on the tank top, and there would appear to be no substantial objection to the adoption of a properly designed open intercostal girder system of equivalent strength to the intercostal plate girder and with efficient riveted connections.

It is suggested that double bottoms constructed on the system of solid floors on every second or third frame space, with skeleton floors between, having efficiently riveted struts to the frame and reverse frame, with channel girder intercostals as shown opposite, should prove an economic advantage to both builder and owner.

PROGRESS WORK IN MARINE ENGINEERING.

The handling of "work in progress" with a view to obviating delay and ensuring the keeping of the predetermined delivery date never fails to exercise the minds of those who constitute the management, whether of a small or a large factory. It is recognised that this important factor deserves unremitting attention, and many the recognised progress system of the entire establishment.

Although circumstances differ in the various factories, even though the product of each is substantially the same, there is no reason why a successful system in one factory should not be adaptable to the needs of another. Modifications would

Order No. 1297 A *Description* 5 Type Y Units *Due* July 26th

For *Other Orders Associated*

From P/F Department.								From B Department.							From X Department.					
No.	Drwg.	Name.	P Com.	F Com.	Mach. Process.			Comp.	No.	Drwg.	Name.	Com.	Com.	Mach. Process.			Comp.	No.	Drwg.	Name.	Mach. Process.				Comp.
5	123/1	Pivot	15/6	30/6	✶	L			5	187/4	Leather Washer	X	X					5	188/3	Securing Plate	✶				
5	187/1	Base for Corrector	18/6	29/6	✶	M			5	„ /4	Inner Securing Ring	X	X					20	„ /4	Screw for ditto	✶	C			
5	„ /2	Securing Nut							10	201/1	Ball Bearings	X	X				30/6	5	„ /5	Retaining Ring					
5	„ /3	Outer Securing Ring																20	„ /6	Screw for ditto	✶		M		
5	191/3	Bracket	27/6															10	123/3	Screw for Bracket	✶				
5	„ /4	Cover for ditto	27/6															5	„ /4	Guide Bracket	✶				
																		5	126/1	Worm Spindle	✶				
																		5	„ /2	Worm Wheel	✶	L			
From T/S Dept.								From TN Dept.																	
5	123/2	Guide Bracket	X	30/6	✶				5	188/1	Shield														
5	192/1	Flange	27/6						5	„ /2	Plate														

P/F Dept.—Pattern shop and foundry. First column, pattern complete; second, casting complete. All castings covered by the order appear under this heading.
T/S Dept.—Tool-room and smithy. First column, tools complete; second, product complete.
B Dept.—Details ordered from outside. Only end (completed) column used.
TN Dept.—Tinsmiths. Only end (completed) column used.
X Dept.—The department responsible for machining and assembling. All details under this heading are made from material ex stores.
✶ Denotes material available for machining. C, M, &c., work in process of machining.

General Arrangement of Progress Chart.

schemes have been devised whereby the specific circumstance is adequately catered for.

The method outlined above was devised and carried into effect some little time ago in a marine engineering establishment, and in the first instance it operated only in connection with one line of manufacture. So successful was it in this direction, however, that before long its scope was extended, and eventually it became undoubtedly be necessary to ensure success in the new field of operation, but there would follow an examination of the system as it stands, and a close study of the conditions under which it would operate. It is because the writer has proved the efficiency of this system that he submits it for the consideration of others, and it is described, for the sake of simplicity, in its original form, operating in connection with but one line of manufacture.

Orders were received for quantities of completed units, ranging from one to ten—that is to say, one order may cover but one unit, another five, and another ten. Owing to the constant changes in design which are associated with certain branches of marine engineering it was not considered expedient to hold stocks of machined component parts, except in very few instances, and as a consequence practically every part associated with the order had to be put into process.

The machining of the component parts, and the subsequent assembling of the unit, was handled by a department which we will call X, this department being interested also in other products. This is mentioned because, when a department is wholly concerned with one line of manufacture, productive planning on a grand scale is permissible, and the importance of progress work is not so apparent. In the case of the factory under review, however, each progress man was in active competition with his fellows, and success was achieved by the one who displayed the greater initiative. Each had an assembling section to satisfy, but all had to draw their supplies of finished components from one machining department.

Supplies of material for machining purposes were drawn from the foundry (castings), smithy (forgings and stampings), and the store (bar stock, &c.) and each progress man was responsible for getting the material early enough to allow an adequate margin for machining, thus taking into consideration the other commitments of the machining department. In the case of castings, the availability of the pattern was the first consideration—if this were not in existence, the pattern shop had to be progressed, whilst if the pattern were in use in connection with another order, arrangements had to be made for its release. The dies and tools for stampings and forgings had to be looked after, and thus it will be seen that a good deal of progressing was necessary before the material was available for machining.

Mr. Brown *Day* Wednesday

Type Y Units

Order.	Quan.	Drwg.	Name of Part.	Section.
1297A	5	123/1	Pivots	Lathe
	5	126/1	Worm Spindle	Ditto
	5	157/1	Base for Corrector	Mill
	20	188/6	Screw for Retaining Ring	Ditto
	20	„ /4	Screw for Securing Plate	Capstan

Table of Work in Hand.

The machining department did not supply the whole of the details required by the assemblers, for certain parts were purchased from outside makers in a finished state, while other parts were produced in factory departments, such as the tinsmiths, &c. So the progress man responsible for one assembling section had to draw the material supplies from various sources, progress each part through the many machining operations, press for delivery of parts from other factory departments and from outside sources, and arrange for the whole to be in the hands of the assemblers early enough to permit the unit being completed in accordance with the delivery date.

Taking into consideration also the fact that he had many such orders to handle, it will be seen that the progress man had an arduous task to perform, and that to ensure success the matter must receive scientific handling. There must be no duplication, no hesitancy, and no wasted time—he must know at once what he has to do, and how to set about doing it.

The details associated with the order were covered by a part list, which gave the source of supply and the departments through which each part had to travel. The system was based on the fact that, to facilitate the progress of work through the shops, it is necessary to have a condensed record of all details, with a view to bringing to the mind of the foreman of the department and also to the progress man, the exact state of affairs, without reference to innumerable papers and dockets of various sizes.

With this end in view, a progress chart was compiled for each order, the details being enumerated in departmental columns. This meant that all castings appeared in one column, all forgings in another, all parts on order from outside makers in a third, and so on. By this means it was easy to see at a glance the details required from any specific department, and this chart was compiled immediately upon receipt of the part list.

The chart (page 357), having been compiled to show all details associated with the order (in departmental columns) is now in active use, and all matters bearing upon the job in question are duly recorded. Thus additions and cancellations, hold-ups and releases, delays and movements, are all recorded by means of documents received, and when at length it is time for the progress man actively to interest himself in the progressing of the various parts, he can see at a glance precisely upon what he must concentrate, and not waste time upon matters which do not need attention.

For example, he will find that certain castings have already been delivered to the machining department, while others have not, and it is upon the latter that he concentrates. When the pattern is completed, the date is entered in the first column, and when the casting is completed, the date is entered in the second column, while, when the casting is actually delivered to the machining department, the first square of the third column is marked (in red ink). The same procedure is adopted in connection with stampings and forgings, the date in the first column denoting the completion of the die or tool, and the date in the second column the completion of the product.

Details which are to be manufactured from bar stock appear under the heading of X department, and when the material is actually received in the machining department the first square is marked in manner similar to that already described. Parts ready for the assemblers received from outside sources, or from other factory departments are entered in the completion column, as shown.

When parts are put in hand for machining, the fact is noted by an entry in the square following the one already marked, this entry taking the form of a letter to denote the section in which the work is being handled. Thus L means lathe section, C capstan, M milling, &c., and as each new operation is put in hand a square contains the entry of the section responsible. A daily list of the parts in hand may be compiled by the progress man and handed to the foreman, this list being illustrated above.

The chart now gives a very clear indication of the progress made, for it shows (1) the number of castings still outstanding, and whether patterns are available; (2) the number of stampings and forgings still outstanding and whether tools, &c., are made; (3) what material is available for machining and which is not yet taken in hand; (4) the precise state of all

work in progress; (5) the details already completed; (6) details still required from outside sources or other factory departments; and (7) a complete record of all matters affecting the progress of the job. With this information at his disposal, the progress man is never at a loss. He can gauge fairly accurately the prospects of meeting the completion date, and if he has any doubt in this connection he can take up the matter promptly with interested parties, without delaying until it is too late for the trouble to be remedied. Further, he can at any time give a concise statement to the management, and one which cannot be disputed. The compiling of the chart does not occupy a deal of time, and its upkeep is a matter of a few minutes daily. It is important that a copy of every document—delivery note, delay form, and official instruction—be sent to the progress man, for it is by means of these that the accuracy of his record is upheld, and any leakage in this connection must have serious results. By the adoption of this system the work of the progress man was lightened, but his effectiveness was considerably increased.

SMALL OIL MOTORS FOR THE NAVY.

An interesting essay on the working of small motor boats in the Navy is contributed by Mr. S. E. Creasy to the current issue of *The Naval Engineering Review*, the organ of the Royal Naval Engineers Benevolent Society. Mr. Creasy expresses the opinion that the machinery installation of some motor picquet boats has not been of the most suitable type; in spite of this, however, it appears that when handled intelligently these boats are more than equal to steamboats, although the ignorance and prejudice displayed toward them is appalling.

A picquet boat fitted with two 60-h.p. Parson's paraffin engines lay on the mud at Invergordon for months and inquiries elicited the information that as 10 gallons of paraffin were consumed an hour when at full speed, it was too expensive to run and therefore a steam picquet boat was used instead. At a most conservative estimate the steamboat must have used 220 lb. of coal per hour at full speed, yet this was considered preferable to using 10 gallons of paraffin, and this is ignoring the expenditure of coal in the steamboat due to raising steam and laying with banked fires, there being no corresponding fuel expenditure in the case of the motor boat. The motor boat was stated to be quite as reliable as the steamboat and no objections were raised on that score.

An attempt to use Diesel-engined picquet boats by the *Dreadnought* ended in failure, quite apart from the fact that this attempt was made 12 years before it should have been, the air compressor was most inefficient and the capacity of the manœuvring air bottles inadequate.

For use in picquet boats two types of internal-combustion engine suggest themselves as being suitable to supersede the steam engine. The first type would be a high speed paraffin engine driving the propeller through a reducing reversing gear, and the second one would be a multi-cylinder engine of the surface-ignition or hot-bulb type running at about 2,350 r.p.m., directly reversible and directly coupled to the propeller.

Another type of boat carried by the larger ships is a 42-ft. sailing launch fitted with a 14-h.p. paraffin engine revolving at high speed. These boats have bluff lines and there is no doubt that a reducing-reversing gear of the Thornycroft type would effect an improvement in the overall efficiency; the engine would have to be installed on a higher level and would be much more accessible than it is at present.

The smaller ships are almost exclusively supplied with motor boats, but one cannot help thinking that it is only considerations of weight, and perhaps fuel, that has led to the exclusion of steamboats.

The great aversion to motor boats throughout the Navy is chiefly due to the fact that a large number of installations have proved very unsatisfactory. This is due to a variety of reasons, viz.: (1) Engines of bad or unsuitable design; (2) inefficient reverse gears; (3) inefficient and untrained personnel.

As regards (1), the Admiralty adopted a policy whereby paraffin became the only fuel for engines of the spark-ignition type; quite rightly, the safety of the ships carrying the boats was considered of paramount importance, and the risk of a petrol fire was too great to allow that fuel to be used. This policy resulted in some very fine paraffin engines being designed, but it also resulted in a number being supplied to His Majesty's Service which were merely petrol engines with the compression slightly reduced, and fitted with bad vaporisers.

As regards (2), the practice of fitting reverse gears of a different make to that of the engine resulted in unsatisfactory running owing to the difficulty of maintaining correct alignment. The system of mounting the reverse gear on an extension of the engine bedplate cannot be commended too highly, since it eliminates noise, with the resultant wear and vibration. The reverse gears themselves are sometimes a source of great trouble, and one well-known make which was supplied in large numbers was probably the cause of more repair work than any other three makes of reverse gear together.

The author's personal experience leads him to the conclusion that the Brooke, Gardner, Kelvin and Mumford reverse gears are the most reliable.

As regards (3), the whole question merits serious attention. There is a good reason for believing that neither engines nor reverse gears receive fair treatment at the hands of the drivers who at present have to be selected in a haphazard fashion. In the writer's ship, for instance, there were two motor boats and not one of the drivers, and not one of the E.R.A.'s had had an official course of instruction. The result has been that fairly successful attempts have had to be made to render the engines foolproof.

In steamboats the policy of duplication is carried to an almost absurd degree, whilst in motor boats nothing is duplicated excepting the ignition system, where battery and coil ignition is sometimes installed in addition to the magneto, chiefly with a view to facilitate easy starting.

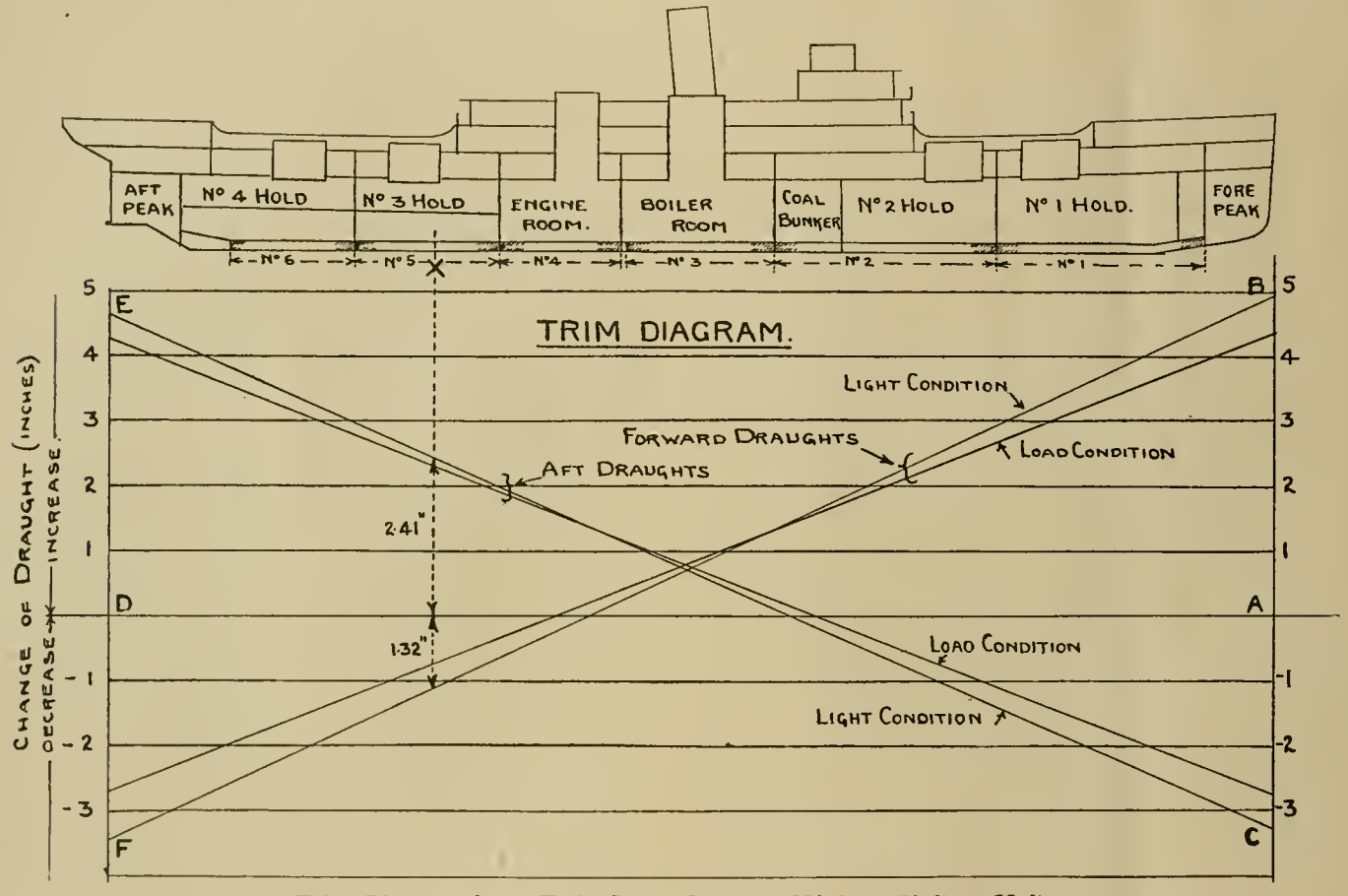
In the writer's opinion it is absolutely essential that oil strainers should be fitted on both the suction and discharge sides of the pump and also that the oil sump should be water-cooled. The use of salt water as a cooling medium is open to objection particularly in weedy, or sandy waters. To keep the temperature sufficiently low, however, the fresh water should be circulated through coolers fixed on the outside of the boat in a similar manner to that of a keel condenser.

A trouble which is rather common with some boats (despite the introduction of inverted U-bends) is that of taking water back through the exhaust pipe, into the engine, which usually occurs when the boat is moored to the boom in rough weather. By the use of a spring-loaded flap this nuisance can be completely eradicated and, if the engine should be started with the flap down, the exhaust pressure will merely force it into the open position. Silencing could be improved considerably by a more general use of the under-water exhaust.

Another cause of noise is detonation, or knocking, in the cylinders due to the use of paraffin as fuel. Russian paraffin is less liable to detonation than other brands of paraffin, but since this is so difficult to obtain, means have to be devised to reduce the noise, although the practice of diluting the mixture of paraffin vapour and oil with cooled exhaust gas has been in existence on industrial oil engines for a number of years, the Penta engine appears to be the only marine motor which adopts this system, despite the fact that a reduction in deterioration is effected.

A CONVENIENT TRIM DIAGRAM.

It is the usual practice of most shipbuilding firms on the completion of a vessel to provide the master with a trim diagram or trim tables, in order that he may determine the trim under any condition of loading. Some of these diagrams require a fair amount of work in their preparation, and when completed are so complicated that they only increase the master's aversion to any form of theoretical naval architecture. The diagram illustrated below has been prepared for many vessels, and being very simple in its application has been favourably received by many captains.



Trim Diagram for a Twin-Screw Steamer 360 ft. x 50 ft. x 28 ft.

CARGO CAPACITIES (BALE).

	Cub. ft.
No. 1 hold	36,532
No. 2 hold	38,420
No. 3 hold	22,524
No. 4 hold	17,540
	115,016

WATER BALLAST (S.W.).

	Tons.
No. 1 tank	115
No. 2 tank	150
No. 3 tank	108
No. 4 tank	97
Fore peak	72
Aft peak	56

FRESH WATER.

	Tons.
No. 3 tank (feed)	128
No. 6 tank	32
COAL (at 45 cub. ft. per ton).	
Cross bunker	332
Boiler room wing (port)	56
Boiler room wing (starboard)	42
	430

The basis of the diagram is the principle of influence lines, which is most commonly used in the design of structures, and the figure shows the changes of draught at the forward and after ends due to the addition of a definite weight at any point. Since the actual change of trim due to an added weight varies as the distance of the point of application from the centre of buoyancy, the changes of draught need only be calculated for two definite positions of the added weight, and any other changes may be found by interpolation.

To illustrate the method, a vessel of the ordinary passenger and cargo type, with the capacities as tabulated above, has been chosen, and the effect of an added weight of 20 tons is shown for the light and load conditions. Dealing with the light condition, the changes of draught caused by sinkage and trim for 20 tons at the forward end is calculated, and these changes are set off at a point A, as shown. Then A B represents the sinkage at the fore end, and A C the lift at the after end. In a similar manner the effect of 20 tons at the after end is worked out, giving the increase of draught aft D E and the decrease of draught forward D F. The lines B F and E C then give the changes of draught forward and aft respectively, and the ordinates at any point give the exact change of draught for a weight of 20 tons applied at that point. For example, if in the light condition a weight of 20 tons is placed at X, the increase of draught aft would be 2·41 in., and the decrease forward would be 1·32 in., as shown on the diagram.

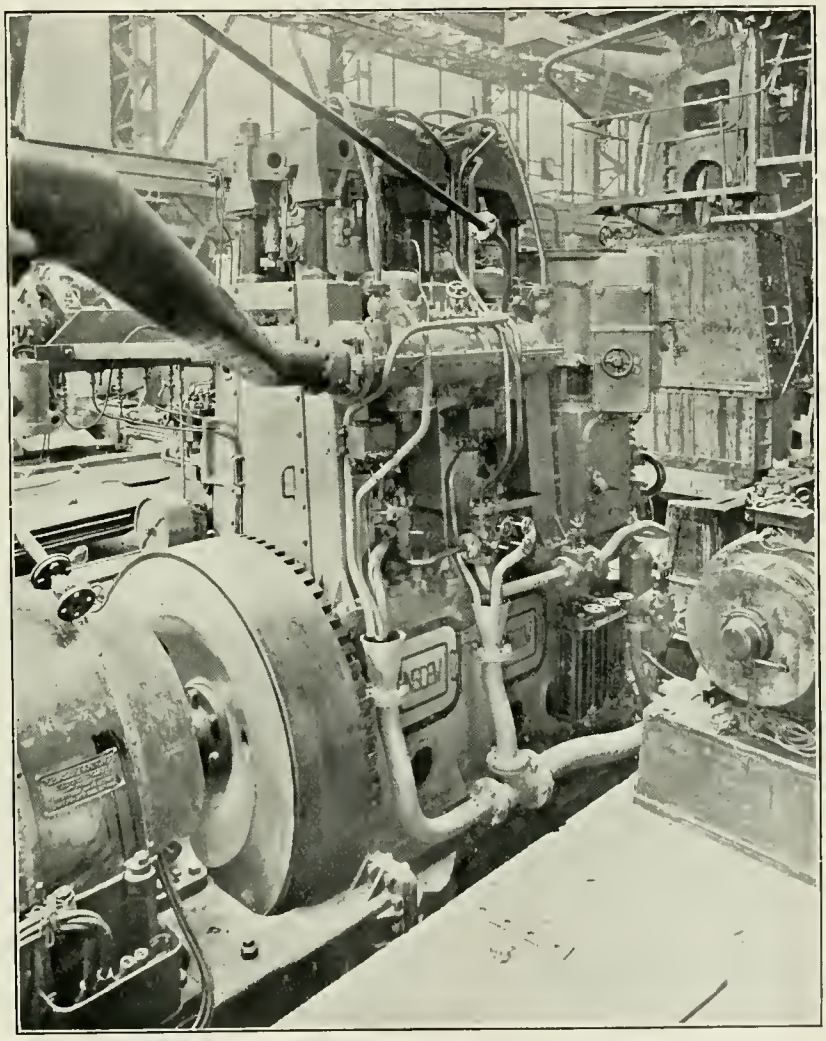
The changes of draught for weights other than the basis are found by proportion; for instance, if 50 tons had been placed at X the effect would have been 2·5 times as great. The trim lines vary slightly with change of draught, and it is sometimes necessary to include intermediate lines between the light and load conditions; in the case of a large cargo vessel it is almost essential to use at least four lines.

An outline profile showing the cargo spaces and their capacities is very useful in conjunction with the diagram, and the illustration shows in a useful form the information required by the ship's officers.

NEW DOUBLE-ACTING TWO-CYCLE DIESEL ENGINE.

Interesting Tests at the North British Diesel Engine Works.

The marine Diesel engine as we know it to-day, whether it be operated on the four-stroke or the two-stroke cycle, suffers from certain inherent weaknesses, and although modern science and research have effected very substantial improvements during the last decade it cannot be said that finality has yet been reached. Not the least of these weaknesses lies in the fact that until recently, with one exception all marine Diesel engines were confined to the single-acting type. Early experiments with double-acting Diesel engines were not attended by a large measure of success, and the difficulties which beset the progress towards a satisfactory double-acting marine engine of the Diesel type have been abundantly manifest in the experience gained with the German-built vessel *Fritz*. The advantages which the double-acting engine possesses over the single-acting engine are many. Thus, a uniform turning effort is applied to the crankshaft and, approximately, double the power is developed in a given cylinder. Lubricating difficulties are greatly reduced by the reversal of pressure, the lack of which in some of the earlier Diesel ships which we have in mind was such an important contributory factor towards their failure. The double-acting engine, other factors remaining unaltered, should manifestly possess substantial advantages over the single-acting engine in the matter of weight and space occupied for any specific power, and given a sound design there is no reason why such should be more complex than that of the single-acting engine. Duplicate fuel valves at the bottom of each cylinder and the employment of scavenging valves in the case of the *Fritz* presented at the outset factors which mitigated against successful operation.

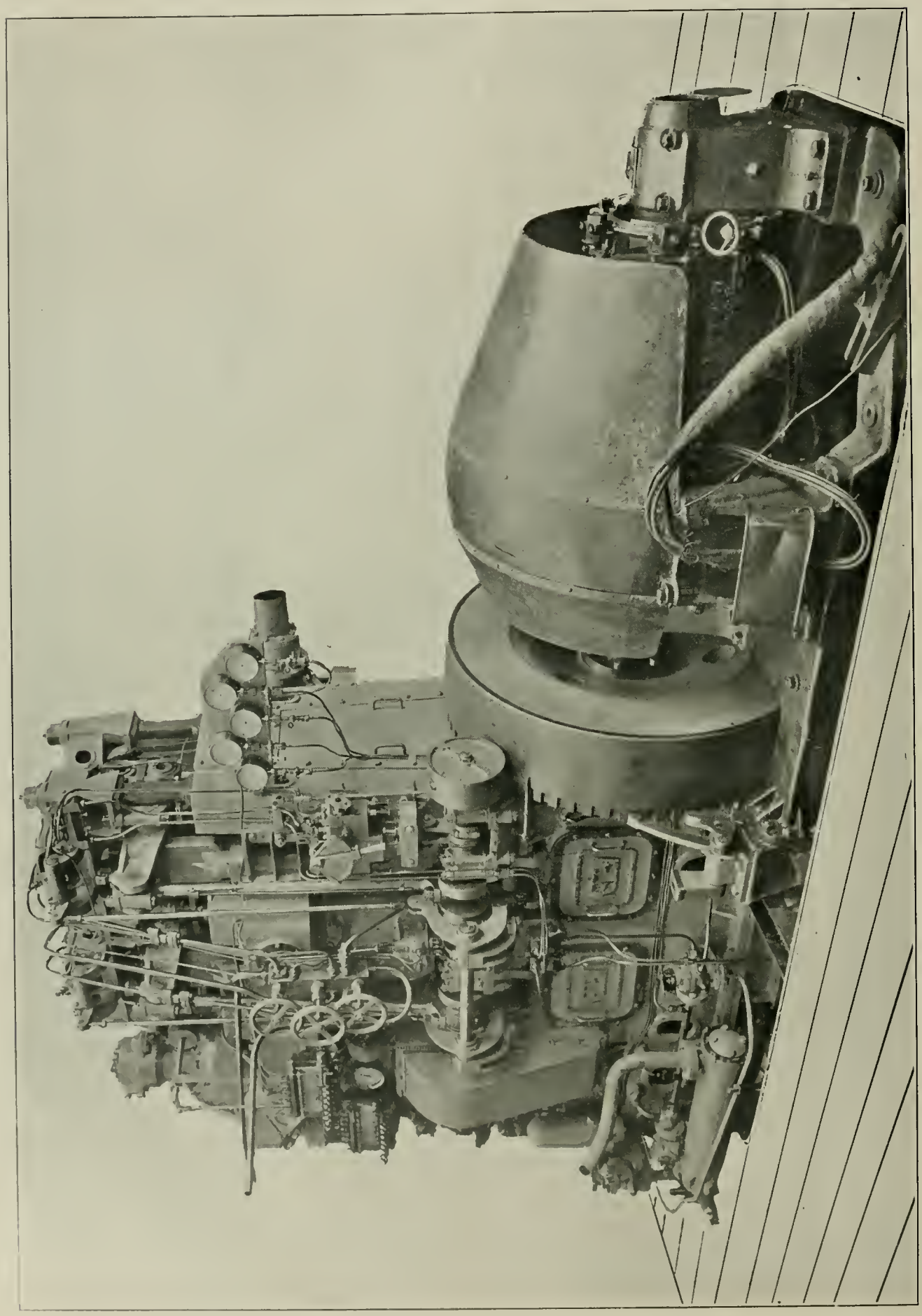


Back View of New North British Diesel Engine.

An entirely new type of two-stroke double-acting engine has been designed and constructed by the North British Diesel Engine Works, of Glasgow, and extensive tests have been carried out at Glasgow. These tests have given the builders such satisfaction that they are now engaged on the construction of a double-acting engine of 2,250 i.h.p., to which we shall refer later. The most outstanding feature of this experimental engine has reference to the cylinder, which reciprocates with the engine, travelling through a distance approximately equal to one-third of the engine stroke. We publish herewith two views of this experimental engine, and on page 364 we give diagrammatic outline drawings by the aid of which the principle on which the engine functions may be readily understood. In passing, it should be said that this engine has two working cylinders 11½ in. diam. by 14½ in. stroke and develops 240 b.h.p. at about 250 r.p.m. The engine is shown direct-coupled to an electric generator, and this engine and generator will shortly be installed as an auxiliary set in one of the large Diesel-engined ships at present being equipped by the builders. The engine consists primarily of an open-ended cylinder a which may be described as two cylinders bolted together. This cylinder, together with its water jacket b and scavenge and exhaust branches c, c_1, d, d_1 is free to reciprocate relatively to two cylinder covers e, e_1, provided at each end of the cylinder a. These covers are virtually stationary pistons and are provided with gas-tight rings so that the cylinder is permitted to move axially in relation to them. A piston f, on both sides of which the gases of combustion act, reciprocates in the cylinder a between the end covers e, e_1. Each cylinder cover is provided with a fuel valve and air starting valve. The piston f is provided with a gudgeon pin g which projects through axial slots v provided in the cylinder a. Crosshead guides k, k_1 are fitted to the ends of the gudgeon pin g. Bearings h, h_1 are provided on the parts of the crosshead guides which are attached to the end of the gudgeon pin g, and these bearings take the connecting rod-top end bushes j, j_1.

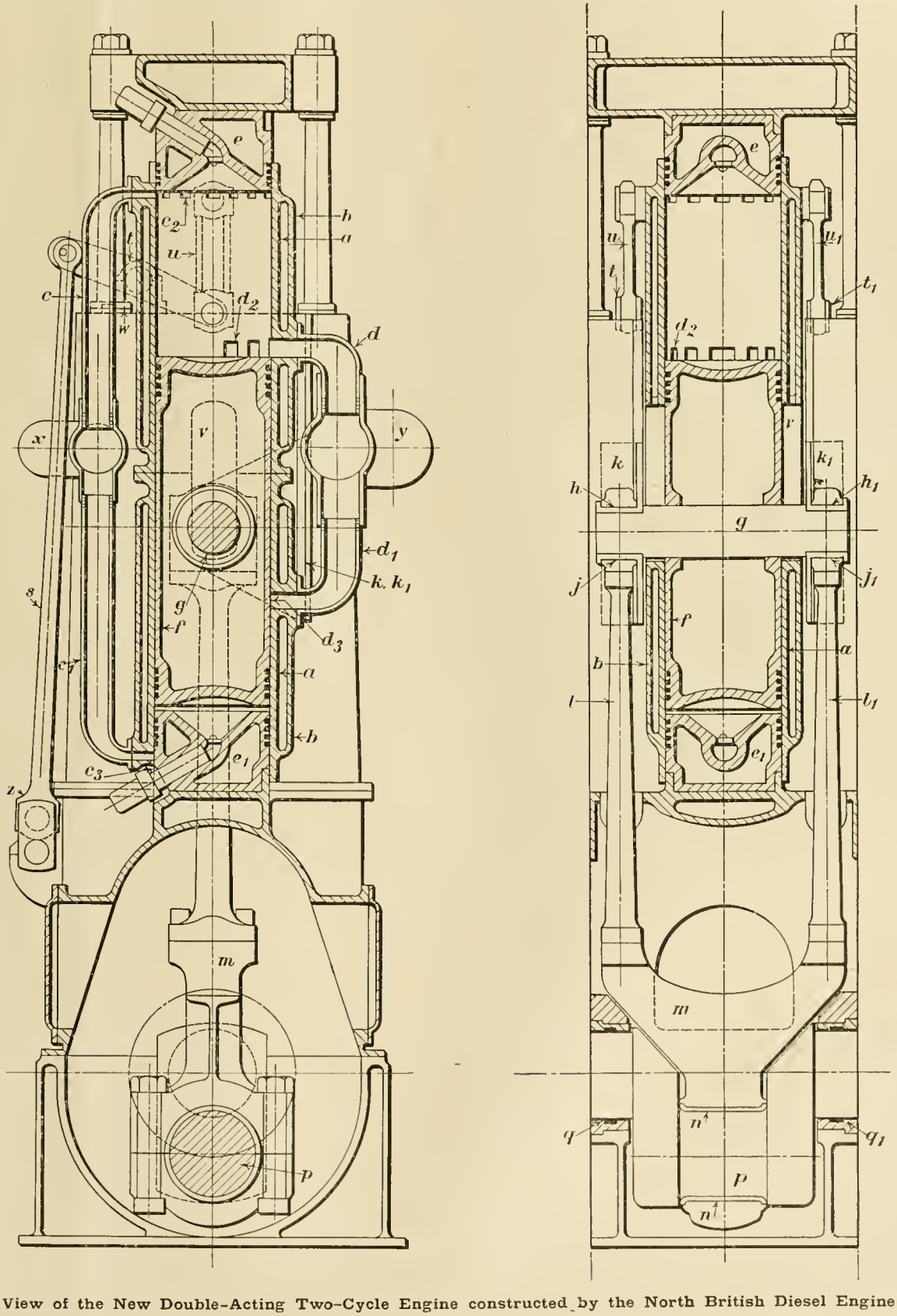
Connecting rods l, l_1 are provided between the crosshead

(*Continued on page* 363.)



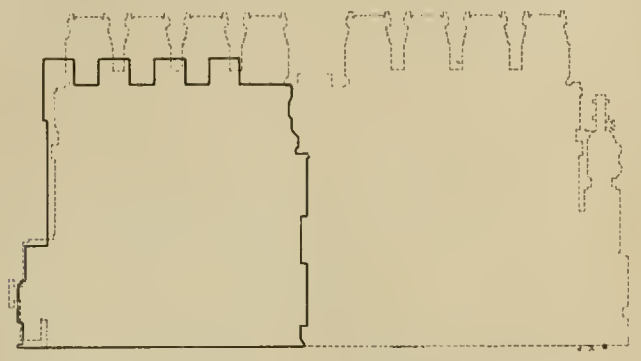
Front View of New Double-Acting Two-Cycle Diesel Engine Built by the North British Diesel Engine Works, Glasgow. (*See page* 361.)

bearings and the fork end m. A bottom end bearing n is provided at the lower end of fork end m, and this bearing operates on the crank p. Crankshaft bearings q, q_1 of the usual form are provided on either side of the crank p. The cylinder a and its water jacket b, together with the scavenge and exhaust pipes c and d, are caused to reciprocate by the crank motion s, t, u, z, the crank end of the auxiliary connecting rod s being attached to a crank z provided on the camshaft. The upper end of the connecting rod s is attached to the beam levers t, t_1 and the centre gudgeon of the levers t is pivoted in brackets w, attached to the engine structure. Links u, u_1 are attached at their top end to trunnions provided on the cylinder, and at their lower ends to the levers t, t_1. The cylinder a, with its water jacket b and its scavenge



Sectional View of the New Double-Acting Two-Cycle Engine constructed by the North British Diesel Engine Works.

and exhaust pipes c and d, travels generally in the same direction as the piston, but at a lower speed than that of the piston. Thus the scavenge ports c_2, c_3 which are supplied with scavenge air pipes c, c_1, are uncovered by the relative



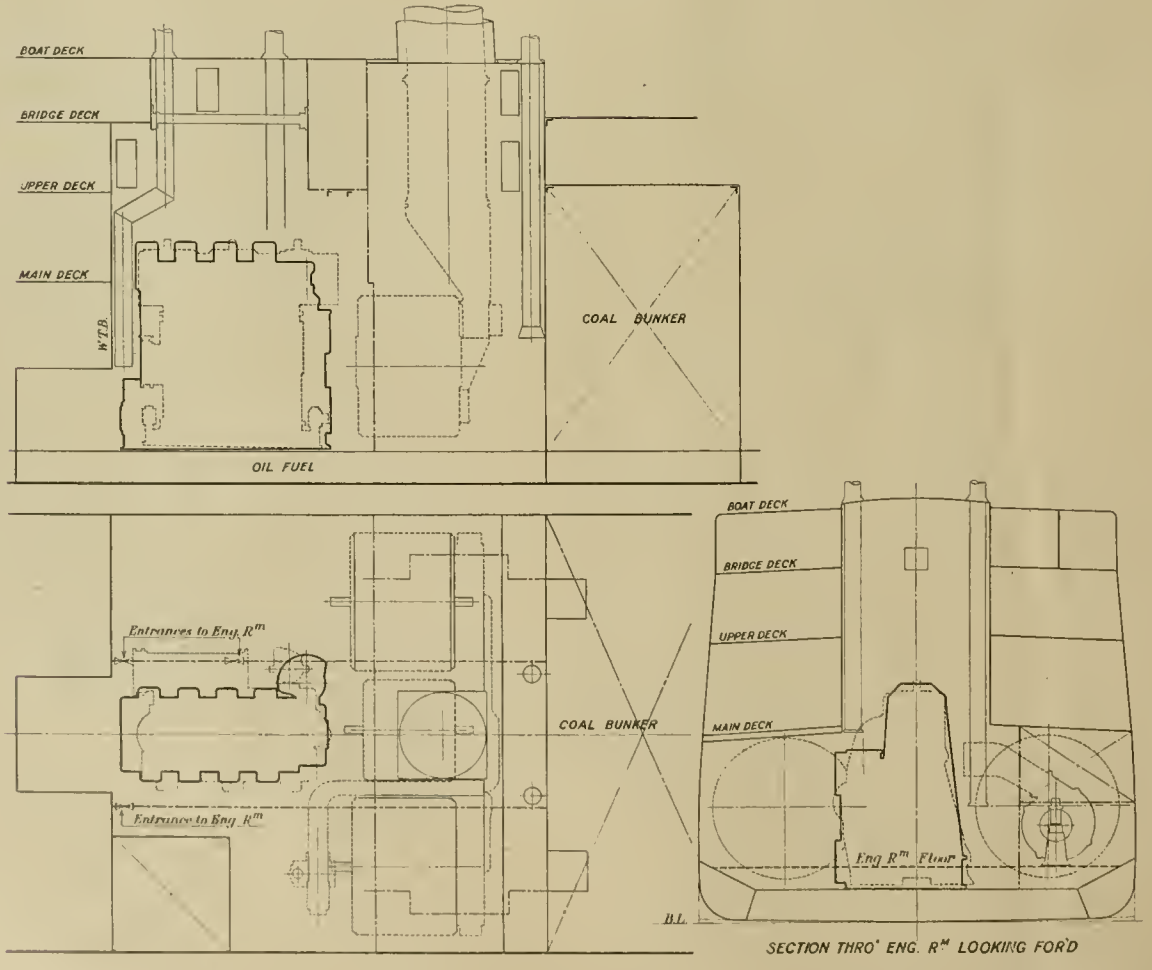
Comparison between New North British Engine (heavy lines) and a Four-Cycle Engine (dotted lines) of 2,000 i.h.p.

movement of the cylinder a to the cylinder covers e, e_1 and the exhaust ports d_2, d_3, through which the exhaust gases pass to pipes d, d_1, are uncovered by the relative movement of the piston f to the cylinder a. It should be noted that although the cylinder is a fairly heavy part of the engine, its travel being comparatively small, the forces involved in moving it are not of a large order. For example, the two rods which drive the cylinder in a 450 b.h.p. unit, although very moderately stressed, are only $1\frac{1}{2}$ in. in diameter.

A stuffing box is provided in the main fixed scavenge supply pipe x for each of the reciprocating scavenge branches c, c_1 which move with the cylinder a. The fixed exhaust manifold y is provided with stuffing boxes in which the moving exhaust branches d, d_1 reciprocate. In the experimental engine these moving branches are uncooled, but in the larger engines to be built water-cooling will be provided. The sliding joints are subjected to very little pressure and reciprocate at a comparatively low speed (about one-third of the main piston speed) and on trial have given no trouble whatever.

Short columns, mounted on the main structure, carry the top-cylinder covers, and the fuel valves are situate in the top and bottom covers, as shown. These valves are operated from the camshaft, which is situate about the level of the flywheel top, the top valves being operated by long link-rods, as seen in the front view of the engine. At the end of the engine, remote from the flywheel, horizontal water-cooling and lubricating pumps are driven from the crankshaft. A three-stage air-compressor and a scavenge pump are driven from a common crank with forked links. The speed of the engine is controlled by throttling the fuel supply to the suction pumps. The engine shown is not reversible.

Several advantages are obtained by the novel design of this engine, and these advantages will be readily appreciated by those familiar with marine oil engines. By causing the cylinder to reciprocate, it becomes possible to provide scavenge and exhaust ports at opposite ends of the cylinder. This, in addition to ensuring perfect scavenge, eliminates certain awkward heat stresses frequently experienced where scavenge and exhaust ports are arranged at the same end of the cylinder.



Comparison between a North British Double-Acting Engine (heavy lines) and a Steam Set (dotted lines) of 2,000 i.h.p

Moreover, this advantage of "through" scavenge has been gained without departing from the normal well-tried form of crankshaft.

The engine is particularly well suited to accommodate expansion due to heat; one of the most serious problems with which Diesel engine designers are faced to-day. The cylinder is entirely free to expand, both axially and radially. In way of the combustion space, it takes the form of a plain cylindrical tube entirely surrounded by cooling water and free from any valve holes. Moreover, the fact that it has a reciprocating motion, which nearly synchronises with that of the piston, reduces the rubbing speed of the piston on the cylinder by about 30 per cent., thereby increasing the life of the cylinder and piston rings.

The cylinder covers, which it should be noted may be removed without breaking high pressure cylinder joints, are also entirely free to expand, both radially and axially, where exposed to the heat of combustion. There is a total absence of heavy cover studs and flanges. The combustion space in the cover is conical in form, the fuel being injected at the apex, which being remote from the piston, minimises the danger of overheating the piston crown. Piston cooling is effected by providing a slot near the middle of the cylinder, and the piston cooling pipes are attached directly to the piston, thus making for greater simplicity and accessibility.

Owing to the long connecting rod ratio, the lateral pressure on the crosshead guide is very low, being about 40 per cent. of that generally adopted in marine Diesel engines. The top and bottom end bearing pressures are also 40 per cent. less than those usually found in single-acting engines; in addition to which the loads are reversed at each stroke, thus contributing towards perfect lubrication of the bearings.

The balance of the engine has been carefully investigated and it has been demonstrated that with any number of working cylinders from 3 to 8 inclusive, a quality of balance can be obtained which compares favourably with that of the four-cylinder marine reciprocating steam engine.

At the tests which we recently attended in Glasgow it was seen that the engine started up with facility and was running on fuel after a few revolutions. The synchronous reciprocating movement of an engine cylinder with that of the piston is more remarkable in the abstract than in the concrete, and to have seen the engine under working conditions is to marvel at the apparent simplicity of the cycle. On a six-hour test a mechanical efficiency of 65 per cent. was obtained, and in no part of the engine was there any suggestion of overheating. This efficiency is to be regarded as highly satisfactory inasmuch as the scavenge pumps and air compressor have been designed with greater relative capacities than will be necessary in later engines.

As already mentioned earlier in this article, the results achieved on this experimental engine have been such as to encourage the builders to proceed with the construction of a large unit of 2,250 i.h.p. As yet, only preliminary details are available, but a general conception of the engine will be possible when it is stated that three cylinders will be provided, each with a diameter of 24½ in. and a piston stroke of 44 in. The engine will develop 2,250 i.h.p. at about 100 r.p.m., with an indicated M.E.P. of 86 lb. per sq. in. A reciprocating scavenge pump will be driven by a crank on the main crankshaft and a three-stage air compressor will be incorporated at the forward end of the engine.

On page 364 we give diagrams illustrating comparisons between a four-cylinder double-acting engine of this type, developing 2,000 i.h.p., and the four-cycle single-acting Diesel engines as installed in the *Domala*. The latter engines were also manufactured by the North British Diesel Engine Works.

The four-cylinder double-acting engine has a 22-in. bore cylinder against 26½ in. in the four-cycle, and weighs exactly 50 per cent. less than the four-cycle engine. It has 50 per cent. fewer main bearings, bottom end bearings, crosshead bearings, and guide shoes, and has only eight cylinder valves in operation at sea against 24 in the case of the four-cycle engine. Moreover, the four-cycle engine has 88 per cent. greater piston rubbing speed than the sliding cylinder double-acting engine. A separate diagram is also given on page 364 showing the comparison between the four-cylinder double-acting Diesel engine and a steam engine of 2,000 i.h.p. It will be seen that the sliding cylinder double-acting engine occupies practically the same space as the steam engine of equal power so that the entire boiler room and bunker space is available as additional cargo space.

An important advantage of this engine is that direct reversible marine engines may be made having any number of cylinders from two to eight inclusive, so that a very large range of powers can be obtained using the same standard unit. If we take for example a 450 h.p. cylinder, this size of cylinder may be used for direct-reversible engines of from 900 h.p. to 3,600 h.p. in single screws, and the maximum power may be increased to 7,200 in twin screws. In manufacturing this engine therefore it will be possible to reduce the number of different sizes of cylinder to a minimum.

It is apparent that in the design of this engine a radical departure from generally accepted ideas of design and construction has been made. The progress of the first large engine of this type to be fitted in a sea-going vessel will be followed with the closest interest by engineers and shipowners alike. The patent has been taken out in the joint names of the North British Diesel Engine Works (1922) Limited, and the inventor, Mr. J. C. M. Maclagan.

TRAINING OF APPRENTICES.

The greatly increased foreign competition with which this country is now faced in the shipbuilding and engineering industries has rendered the question of the training of apprentices one of paramount importance.

For a number of years this question has received the serious consideration of John I. Thornycroft & Co. Limited, and in this connection we are advised that they have in operation a highly satisfactory system which, it is claimed, has eliminated most of the difficulties hitherto encountered in the education of students for both the mechanical and administrative sides of an engineering works. The success of this system lies in the fact that the theoretical and practical trainings run concurrently during the working day, thereby giving the student the benefit of access to the wide and varied experience of the works' staff, and also enabling him to understand the "reason why" of his work in the shops, while eliminating the necessity for study when in a tired, non-receptive condition after a day's work. Another important item in the system is that the students are graded according to ability in small classes, thereby ensuring individual attention and an even rate of progress.

The efficiency of the scheme is demonstrated by the following gratifying results at the recent examination of the Institution of Mechanical Engineers, at which the undermentioned eleven pupils and apprentices passed the Graduateship stage:—J. A. G. Bowen, J. R. Cleave, B. M. Grace-White, W. H. Julian, R. V. Knowles, B. C. Oldham, J. R. Pearson, A. E. Read, A. J. Romer, J. F. Rose, G. M. B. Small; and R. W. Long passed the Associate Membership Examination of the same Institution.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Vegetable Oils for Internal Combustion Engines.

In such places as the Congo, where the scarcity and excessive price makes the use of petrol either impossible or prohibitive, attention is being increasingly directed to the possibilities of such vegetable oils as palm and arachis oil for the running of internal combustion engines. In West Africa, where skilled engineers are scarce, the internal combustion-engined river vessel is becoming popular, owing to the saving of trained personnel associated with its use. Several well-known engines have been successfully run on vegetable oil, and this article gives some interesting comparisons. Among these engines are the Gardner, the Kromhout, the Ansaldo and the Anglo-Belgian Co.'s motor. Trials made on a Weyher-Richemond engine, which is intermediate between a Diesel and semi-Diesel and which has a special fuel pump that can be adjusted for oils of varying nature and viscosity, show that this engine can be quite economically run, in the tropics, on palm oil alone. The actual oil used had a calorific power of 9,350, and the resulting consumption was ·554 lb. per b.h.p. hour. The corresponding consumption of petrol of 10,000 calories was ·460 lb. per b.h.p. hour. Further experience, using arachis oil of 9,400 calories, was ·545 lb. per b.h.p. hour. Similar trials on Ruston-Proctor engines running on oil supplied by Lever Bros. showed, for a 15 h.p. set, consumptions varying from ·68 lb. per b.h.p. hour at 7 h.p. up to ·545 lb. at 16 h.p., and with a 42 h.p. set at 9 h.p. ·56 lb., and at 45 h.p. ·502 lb. These figures show that the present position of the use of vegetable oils is past the experimental stage, and photographs are given of actual vessels which are successfully running on vegetable oil.—*Bulletin Techn. d. B.V.*, July, 1922, p. 159; 3 pp.; 5 *ff.*

The Design of Mast Shrouds and Stays.

To determine the distribution of stress in a mast structure and its related stays is a very complicated procedure. The whole system is an acutely indeterminate structure and its solution involves a good deal of work. The following article has been written to amplify the author's remarks on Dr. Gutschow's recent paper on the design of masts and stays, read before the German Institution of Naval Architects. The article by no means offers a simple method of analysis, but shows, however, for a given disposition of stays how the ratios of their cross-sectional area can be deduced. This ratio is shown to be independent of the absolute load on the system, and this absolute load is only used for the calculation of the individual areas of the stays. A considerable number of complicated-looking formulæ are deduced for several dispositions of stays, and, after introducing several selected assumptions, these formulæ become somewhat simplified. The applications of the formulæ are described in general terms, but, unfortunately, no numerical examples, which might have served to illustrate the application and utility of the method, are included in the article.—*C. von der Steinen, Werft, Reederei, Hafen*, May 22, June 7 1922; p. 308, 345; 7 pp.; 13 *ff.*

Condenser Air Pump Research.

This research has been undertaken to determine whether the general objection to steam-ejector air pumps is any longer justifiable. The experiments were carried out by Dr. Hoefer at the Kaiserlichen Werft, Kiel. The results of experiments on the author's own type of steam-ejector are first detailed, and the influence of the humidity of the air upon the vacuum investigated. Next, a complete research is made into the performance of a piston air pump, and the results obtained are compared with those previously derived from the ejector research. Reference is next made to the researches of Grünewald on water-ejector air pumps, and the results there obtained are also compared with the air-ejector results. A similar comparison is made between the water-ejector and piston air pumps. Reviewing the whole subject from a marine engineering standpoint, the author unhesitatingly recommends the adoption of the steam-ejector pump because of the following advantages:—No moving parts, no lubricating oil, greater ease and simplicity of working and control, cheapness, lightness and smallness. The greater steam consumption with the ejector is claimed to be no disadvantage, because the exhaust steam can be used for feed-water heating. The article, although very complete, is itself an abstract of the author's complete report, which is published in No. 253 of the Vereines Deutscher Ingenieure research bulletins.—*Dr. K. Hoefer, Z.d.V.d..I*, July 22, 1922; p. 723; 6 pp.; 14 *ff.*

Alignment Charts for some Simple Strength Problems.

The article first illustrates the practical advantages possessed by the double or correlated scale over the ordinary graph method of showing the relation between two variables, and shows how these former can be simply constructed. This principle is applied to the construction of charts giving the moments of resistance and inertia of several simple sections, such as a circle, hexagon, octagon and square, in terms of their principal dimensions. Next, an alignment chart for steel shafts, expressing the relation between horse-power, kilowatts, revolutions, permissible torque and safe diameter is described and constructed. Next, a further chart, giving the moments of inertia of rectangular, elliptical and triangular sections is described, and, finally, another chart is given from which the moments of resistance and inertia of hollow cylinders can be immediately obtained. This article deals principally with the geometrical properties of sections usually met with in machine design, and in a further article the author is to deal with such problems as the angular and linear deflections of shafts and beams.—*W. Vogel, Werkstattstechnik*, July 1, 1922, p. 373; 5 pp.; 7 *ff.*

Planimeter Theory.

Although the use of the planimeter and integrator have become almost indispensable in shipbuilding calculations, the author claims that few who use these instruments are acquainted with the fundamental theory upon which their construction is based. This he suggests is due to the fact that the usual demonstration of this theory is shrouded in higher mathematics. In this article nothing more complicated than simple algebra and trigonometry is used. The principle of the method consists in correlating the principal dimensions and movement of the instrument with the dimensions and area of a basis rectangle swept out by the tracing pointer. From this simple case the validity of the extension of the method to the obtaining the area of any irregular-shaped figure is easily established. Different proofs are used for the integrator or linear planimeter as it is called, and the ordinary polar planimeter. Similar proofs are, however, given in several English text-books, to which reference should naturally preferably be made.—*O. Richter, Schiffbau*, June 28, July, 1922, p. I, 132, I, 157; 5 pp.; 7 *ff.*

Application of Reduction Gearing in Internal-Combustion Engined Fishing Vessels.

The principle that the prime mover and the propeller should be run at their respectively most efficient revolutions is universally recognised as an axiom in marine engineering design. The considerable economies which have been effected in fuel consumption by the introduction of the geared as compared with the directly-driven turbine is the classic example of the truth of the principle. With the present development of the internal-combustion engine of small powers which has emanated from land motor practice, the high revolutions of the paraffin and petrol motor present the same problem as the directly-driven turbine, when applied to the propulsion of such small craft as fishing vessels, &c. This article shows the feasibility of the application of reduction gearing to such vessels when driven with the increasingly popular paraffin motor. The special case of a fishing vessel 66 ft. long, 12·2 ft. beam, 9·8 ft. beam, 5·6 ft. draft, with a displacement of 70 tons is considered. At a speed of 8 knots the e.h.p. absorbed by this vessel will be about 25·25. With a two-bladed propeller of 35 per cent. disc area ratio, 5 per cent. blade thickness ratio, and, for this type of vessel, a wake factor of ·30 can be assumed. From a diagram of propeller efficiency for this type of screw, a second diagram, giving the diameter and pitch and efficiency of the propeller, is constructed on a base of revolutions. The case of the motor directly coupled is first considered. The motor works at 6 revolutions per second, and for this condition the best propeller has an efficiency of 61½ per cent. The resulting overall efficiency is estimated at 58·3 per cent., and thus

the requisite b.h.p. of the motor is 43·5. The propeller diameter is 3·6 ft.; pitch, 2·45 ft.; pitch ratio, ·68. Next the case of the geared propeller is dealt with. A maximum propeller diameter of 5·4 ft. is chosen. This, for the best propeller, has an efficiency of 71½ per cent., with a pitch ratio of unity. The requisite revolutions are now only 2½ per second, and the overall efficiency being estimated at 63 per cent., the b.h.p. is 40. Thus, by gearing down the propeller a reduction of 3½ b.h.p. is effected. This reduction corresponds to the saving of 1 kg. of oil per hour. The same vessel is examined at a speed of 7 knots. In this case the b.h.p. is reduced from 40½ to 36 by use of reduction gearing. This reduction of power of roughly 10 per cent. is put forward as a sufficient justification for the fitting of reduction gearing.—*Skibsbygning, No.* 1/2, 1922, p. 2; 3 pp.; 2 *ff.*

Condenser Tube Corrosion and Leakage.

The destructive effects of salt water on condensers and boilers are well known, and much thought has been bestowed upon the elimination their contributory causes. With boilers, where progress has been in the direction of the water-tube type, the occurrence of priming is even more likely than with the older types, for recent experience has shown that a salinity of two parts in a thousand is sufficient to produce appreciable priming. The salt water circulating in the condenser, promoting the corrosion of the condenser tubes, ultimately leaks into the condensate and thus, as feed water, returns to the boiler. In modern installations with sensitive water-tube boilers, the question of condenser tube corrosion is thus becoming more and more important. In this article the various methods of tube preparation and protection which have been adopted from time to time in the German Navy are briefly discussed. These methods consist of the usual lead external and internal covering of the tubes, their arranging vertically instead of horizontally, the use of zinc plates, and more recently the Cumberland electrical device. All of these methods have been shown to possess some drawback or other, and no precise solution apparently exists. The article concludes with an interesting description of the last and, incidently, the maiden voyage of the S.M.S. *Dresden* to Scapa Flow. During the voyage the salinity of the feed water continued inexplicably to increase and ultimately priming became so bad that the turbine machinery became unworkable, with a result that the then latest addition to the German fleet had to be towed to Scapa by the S.M.S. *Konig*. The importance of the avoidance of condenser tube corrosion was thus very forcibly demonstrated. The author suggests as the only immediate policy the increasing of the amount of fresh water carried, rather than evaporating salt water on board.—*L. Jacks, Marine Rundschau*, July-August, 1922, p. 300; 5 pp.; 3 *ff.*

Utilisation of Waste Heat in Diesel Engines.

The general problem of the utilisation of waste heat in Diesel engines is first considered, and the progress which has been made in land machinery contrasted with the somewhat meagre progress at present evident in marine installations. Next the more important methods at present in use are considered, these being the Still engine and the Sperry compound Diesel. The performance of this latter is somewhat discredited by the author, who points out that but for a difference in the design of the exhaust valves the machine is identical with that tried most unsuccessfully and rejected as far back as 1896 by the Maschinenfabrik Augsburg. Next, the author considers an installation composed of the Diesel engine proper coupled to a low-pressure turbine, which makes use of the full expansion of the gas, and which should be as economical as the Still engine and structurally simpler. The low-pressure gas turbine is quite a different problem from that of the high-pressure gas turbine, and after considering the general thermodynamic features of such an installation, the author outlines its possible application to a two-stroke and four-stroke Diesel respectively. Applied to the two-stroke an increase of indicated power of 13·3 per cent. is estimated as compared with the 12·25 per cent. increase in the fuel engine obtained in the Still engine from the work of the steam. The corresponding estimated increase with a four-stroke Diesel is 8·75 per cent. The constructional problems of the gas turbine are next reviewed and the relation of the diverse problems of the high and low-pressure gas turbines are carefully considered. Finally, the author considers the question of overload with a two-stroke Diesel and low-pressure turbine installation, and whilst theoretically increased efficiency can be obtained, the higher resulting temperatures reduces the problem to one of metallurgy and one which can only be solved by experience. The article forms an interesting contribution to the subject.—*F. Modugno, Rivista Marittima*, June, 1922, p. 869; 30 pp.; 4 *ff.*

Thermal Conductivity of Liquids, Insulators and Metals.

This article communicates the results of important research work which has been carried out by the author on the thermal conductivity of water, oils, aluminium and its alloys, and nickel steel. The methods of carrying out the experiments are closely described and the fundamental theory upon which these methods are based is very fully gone into. In piston design the desire to reduce the reciprocating weight as much as possible has led to the introduction of aluminium pistons. The problem is to produce an alloy of high conductivity and strength, and low weight and coefficient of thermal expansion. This research shows the decided superiority of aluminium for this purpose. The results for nickel steel which is a relatively poor conductor of high strength, show that it should be very suitable for many uncommon applications in engineering. These are such as thermometer pockets in high-pressure steam pipes, refrigerating-engine cylinders, cylinders, pistons, &c., of uniflow engines. The whole lesson of the research brings out the importance of a sound knowledge of thermal as well as the other metallurgical properties of metals, in the design of machinery.—*Max Jacob. Z.d.V.d.I.*, July 8, 1922, p. 688; 5½ pp.; 4 *ff.*

Dutch Standard Sidelights.

Particulars are published of the standard sidelights which have been recently drawn up by the Dutch Committee for the standardisation of ship details, and which, subject to no adverse criticisms being received within one month of publication, are presumably to be adopted. Eleven standard sheets are given. The first of the series forms the key diagram and contains such valuable information as principal dimensions, material, specification and approximate weights of the various patterns. The second sheet contains all information relating to the ordering of each detail comprising the sidelight. The remaining nine sheets give the detail dimensions of standard sidelights of clear "light" diameters, ranging from 150 mm. by grades of 25 mm. to a diameter of 250 mm., and then by grades of 50 mm. to a maximum diameter of 450 mm. The German standard sidelights have been closely adhered to, and in the absence of a British standard, copies of these Dutch standards have been sent to the British Standards Association for their criticism. A study of the Dutch sheets reveals several interesting features. Principal among these is that in dimensions where latitude can reasonably exist, care has been taken to specify the tolerance limits. For instance, in the diameter of the glass a tolerance of + 1 mm. is permitted. The design of the sheets is carefully carried out and considerable information is given on them.—*Het Schip*, July 14, 1922, p. 199; 3½ pp.; 11 *ff.*

Simplified Stability Calculations.

The oft-expressed desire for the simplification of existing methods of stability calculation has led the author to reduce considerably the amount of labour usual in this work by introducing a method which is a simple modification of the well-known Barnes method of wedges. As was recently proposed by Nicol and Herner (and earlier by several French writers such as Doyere, &c.), the author makes use of the buttock integrals, and by means of superimposed tracing paper the inclined water-line is obtained by constructing an auxiliary diagram of wedge volume. This diagram should have, of course, equal positive and negative areas to fulfil the condition of constant displacement. With a little practice it is claimed that this actual diagram can be dispensed with and the correct water-line drawn in by the eye alone. The water-lines are thus drawn in for the usual angular intervals and the wedge volumes and moments calculated in tabular form. The wedge volume figures show the accuracy of the placing of the water-line and from the wedge moment the value of the righting arm is immediately obtained. Thus all the information which is usually required for a stability calculation at constant displacement is very quickly obtained. The author compares the method with those of Barnes, Nicol, Herner, and its advantages are summarised as follows:—Compared to the Barnes, it is simpler and the correction for layer and calculation of the moment of inertia of inclined waterplane are eliminated. Further, the water-line is more closely determined and the righting arm for small angles is more accurately assessed. Compared to the Nicol and Herner (which are practically identical) the new method eliminates the calculation of the vertical position of the centre of buoyancy and takes erections more accurately into account, gives the position of the inclined water-line more correctly, and reduces all calculations to a minimum. The method is claimed to lend itself to purely mechanical treatment, and a description of this treatment is to be published shortly.—*Dr. G. Kempf, Werft, Reederei, Hafen*, July 7, 1922, p. 395; 3 pp.; 4 *ff.*

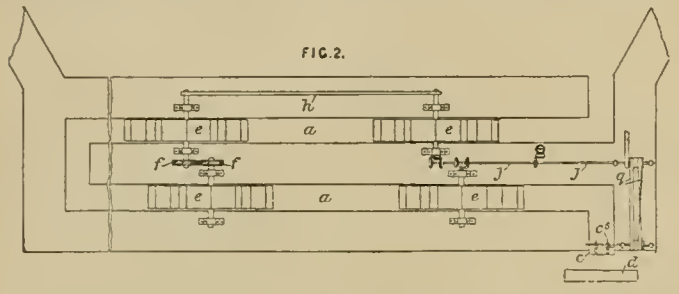
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 180,001. Turbines.

Goudie, T. B., Ewanrigg, and Goudie, J. C., Craiglee, both in Burnbank, Hamilton, Lanarkshire, and Goudie, W., 11, Murray Avenue, Kilmarnock. February 10, 1921, *No.* 4,721. [*Class* 110 (ii).]

Apparatus for utilizing tidal energy comprises one or more water wheels *e* driving a mainshaft *j*, through a clutch device so that the shaft rotates in one direction only. Admission of the water through

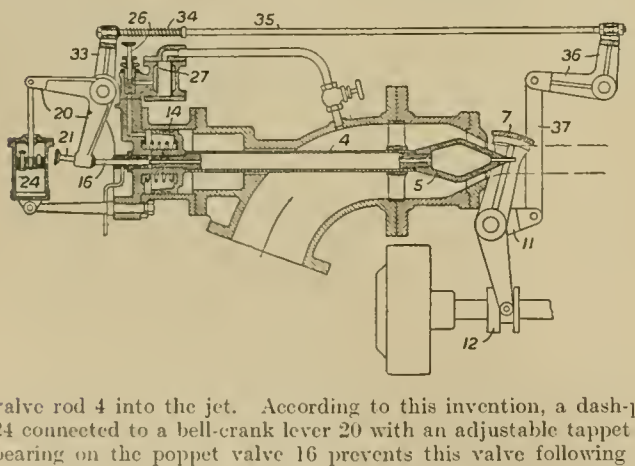


a channel *a* is regulated by a governor-controlled sluice *c*. A screen *d* is arranged in front of the inlet to the channel *a*. The sluice *c* is operated by worm gear c^5 driven from the main shaft *j* by belts *q*, moved by a governor-controlled belt shifter. In Fig. 2 four wheels are shown, one pair connected together by gearing *f* and connected with the other pair through the mechanism *h*.

No. 180,386. Turbines.

Gilkes & Co., Limited, G., and Thorpe, G. E. T., Kendal, Westmoreland. January 26, 1921, *No.* 3,190. [*Class* 110 (iii).]

In control gear for hydraulic turbines comprising a deflector 7 and a nozzle spear valve 5 the pressure fluid from the nozzle inlet has direct access to one side of a piston 14 on the spear valve rod 4, and on the other side the inflow is adjusted by a valve 26 and the outflow regulated by a poppet valve 16 bearing on an outlet port in the piston through which this pressure fluid passes along the hollow

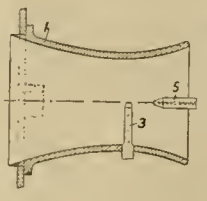


valve rod 4 into the jet. According to this invention, a dash-pot 24 connected to a bell-crank lever 20 with an adjustable tappet 21 bearing on the poppet valve 16 prevents this valve following up the piston too quickly but allows its quick return. In operation, on a rise of speed occurring, the deflector 7 connected to a governor sleeve 12 immediately masks part of the jet and the link-work 11, 37, 36, 35 compresses a spring 34 bearing on a lever 33 of the bell-crank lever 20 so that the poppet valve 16 moves forward but only slowly by reason of the dash-pot 24, the outlet behind the piston 14 being therefore closed, the pressure increases and the spear valve 5 moves slowly forward to close the jet and at the same time the deflector 7 moves out of the jet. On a fall of speed, the link-work positively rotates the bell-crank lever 20 and the pressure returns the poppet valve 16. A filter 27 is provided for the pressure fluid before it reaches the valve 26.

No. 180,461. Furnaces.

Clayton & Shuttleworth Limited, Robson, P. W., Wimbush, H. L., and Jones, E. W., Stamp End Works, Lincoln. March 14, 1921, *No.* 7,997. [*Classes* 51 (i) *and* 75 (i).]

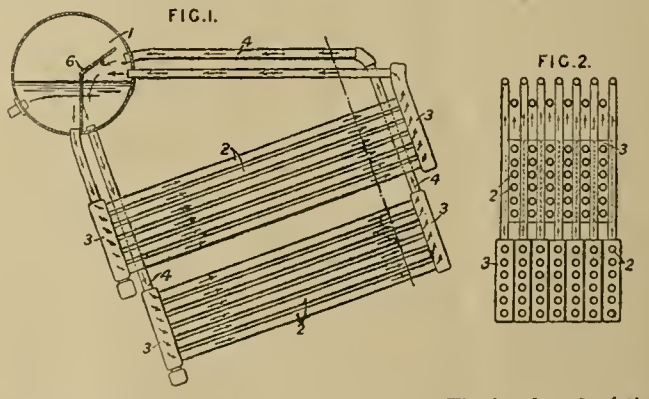
In a liquid-fuel supply system for steam-boiler furnaces of the kind in which the fuel supply is regulated in accordance with the rate of steam generation, comprising a substantially vertical fuel-supply pipe 3 below the upper open end of which the liquid fuel is automatically maintained at a constant level and a jet 5 disposed to direct steam above the fuel-supply pipe to atomise the fuel and mix it with air entering the tube 1, the steam jet is connected directly to the valve chest of an engine so that steam supplied to the jet is varied in accordance with the demand for steam from the boiler. The steam supply to the jet may be controlled by a separate valve which is operated in synchronism with the main valve of the engine or cut-off valve of the boiler. A by-pass pipe may convey steam from the boiler, or from some other source of steam supply for starting-up the boiler, to the jet 5, when steam is not being supplied to the engine, and such by-pass may be utilised for the supply of air to the jet when steam is not available.



No. 180,511. Steam-generators.

Clayton & Shuttleworth Limited, Stamp End Works, and Robson, P. W., Dunelm House, Church Lane, both in Lincoln, and McGregor, R., 158, *Balfour Road, Ilford, Essex. April* 13, 1921, *No.* 10,806. [*Class* 123 (ii).]

In a water-tube boiler having groups of water tubes opening into headers connected to an upper drum, two or more upper and lower groups of tubes arranged in vertical rows are connected separately to the drum, the rows in each group being in staggered relationship



with the rows of the other group or groups. The headers 3 of the lower group of tubes 2 are connected to the transverse drum 1 by pipes 4 passing between the tubes of the upper group of tubes. A partition 6 in the drum directs the water circulation first through the upper group and then through the lower group of tubes. The drum may be arranged longitudinally.

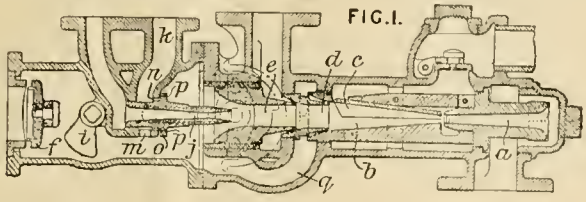
No. 180,628. Injectors.

Metcalfe, R. D., The Mount, Romiley, and Metcalfe, J. C., Sheen Bank, Marple, both in Cheshire. January 7, 1922, *No.* 571. *Convention date, May* 24, 1921. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Class* 71.]

Relates to exhaust steam injectors for steam boilers normally employing exhaust steam at atmospheric pressure as the inducing fluid, but operable also by live steam throttled down to that pressure. Exhaust steam flows through a valve *f*, that may be closed by a handle-operated cam *i*, to the steam nozzle *e*, water cone *d*, and the diffuser consisting of a combining-cone *b* with self-starting flap *c* and a delivery cone *a*. Live steam at boiler pressure to assist the

exhaust supply enters by a steam nozzle *j*. There is also a supply, through the pipe *k*, of live steam throttled to atmospheric pressure that enters an annular passage *n* and issues by a ring *o* of nozzle-like apertures *p* into the main steam nozzle *e*, an outlet *m* serving to prevent formation of a vacuum around the valve *f*. Steam also

FIG. 1.



diffuses into the injector through the space between the ring *o* and the face of the throttled steam supply passage *k*, and a supplementary supply is provided by a passage *q* to become operative between the water cone *d* and the combining-cone *b* in series with the steam passing through the main steam cone.

No. 181,377. Turbines.

Dufour, L., 6, *Route de Florissant, Geneva. June* 9, 1922, *No.* 16090. *Convention date, June* 10, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 110 (i) *and* 110 (iii).]

The blade-wheels of axial-flow combustion turbines are constructed to act also as centrifugal compressors for compressing comparatively cool air and gases which in passing cool the blade-wheels. Each wheel b^1 . . b^5 is formed like a centrifugal impeller with a disk *b*, Fig. 3, having ribs or blades c^1 on which a disk *i* is shrunk or screwed. Each wheel carries (1) radially projecting blades *j* co-operating with the axial-flow nozzles *m*, and (2) continuations of these blades with or without other blades which suck air or gases from a central eye *e* and deliver it through diffuser blades and passages to the eye of the next wheel, partitions *r*, Fig. 2, separating the com-

FIG 1.

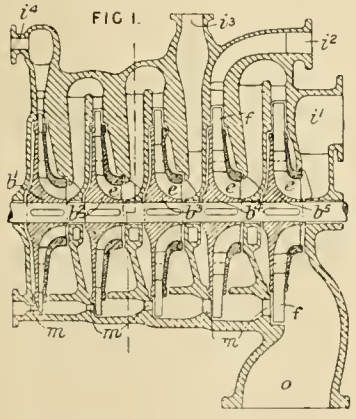
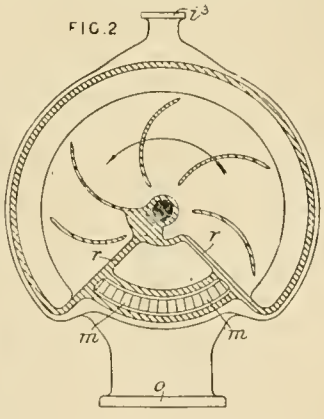


FIG. 2



pressor part of the casing from the turbine part *m*. Air for combustion is drawn in through an inlet i^3, compressed by the wheels b^3, b^2, b^1, and led by an outlet i^1 to the combustion chambers. The hot gases flow through the series of guide-blades *m* and blade-wheels, and are discharged at a sub-atmospheric pressure through an outlet *o* to a cooler, after which they are led through a passage i^1 and compressed by the wheels b^5, b^4 up to atmospheric pressure, discharging through an outlet i^2. The wheel blades may be inclined to the radius, Fig. 14, and given different lengths *a* a^1, a^2. They may be secured to the disks *b*, *i*, Fig. 5, by one or more pairs of lugs *o* and distance-pieces engaging the same grooves. There may be several blade-wheels in each pressure stage. External compressors may be used in combination with the blade-wheels, and portions only of the air or gases may be handled by the blade-wheel compressors. Blades with an inlet angle of at least 40 deg. are used for certain pressure stages. By multiplying the partitions *r*, Fig. 2, there may be provided two or more turbine sections separated by compressor sections.

FIG. 5.

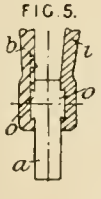


FIG. 3.

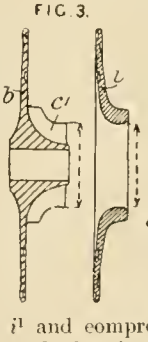


FIG. 14.

No. 181,468. Raising Damaged Ships.

Pearce, R. W., 46, *Orsett Road, Grays, Essex. March* 11, 1921. *No.* 7718. [*Classes* 68 (ii) *and* 113 (i).]

FIG. 1.

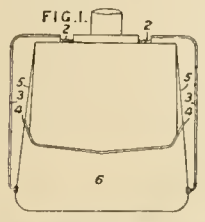


FIG. 2.

Apparatus for lifting the bow or stern of a damaged vessel out of the water to effect repairs, or for raising sunken ships, comprises an inflatable air bag 6 made of canvas treated with rubber solution, and provided with wooden rollers 4 threaded on iron bars linked by chain couplings 10 along its upper edges, ropes 5 by means of which it may be hauled under and attached to the vessel, and armoured air-pipes 3 connecting it to air-pumps 2 driven by the ship's winches. Ropes 7 are sewn to the upper surface of the bag to prevent chafing. A non-return valve is located between the delivery side of the air-pump and the air-pipe 3.

No. 181,495. Steam-generators.

Watson, G., Walter House, Bedford Street, Strand, London, and Hetherington, F., Fern Bank, Penrith, Cumberland, March 16, 1921, *No.* 8214. [*Classes* 51 (i) *and* 123 (ii).]

Vertical boilers.—A vertical boiler B, Fig. 4, sits upon an independently constructed fire-box and combustion chamber A, formed as a feed-tank, in which feed-water, not under pressure, is heated before injection into the boiler, for example by an injector K. The water-level in the feed-tank is maintained above the fire-box proper by a drip-cock N, and cleaning doors L are provided for the removal of sediment, &c., deposited from the feed-water. An opening P closed by a fire-door Q is left in one side of the tank for stoking the boiler, and, in the case of a tubular boiler, inclined smoke tubes C, secured in top and bottom tube-plates D, E respectively, lead to an annular smoke-box G surrounding a steam space F, in which the water-level is so maintained that the tubes C are always immersed. The chimney H and the top of the smoke-box G may be hinged back to facilitate brushing through of the smoke tubes C. In a modified form, the feed-tank is made in segmental sections, means being provided for maintaining a high uniform water-level in all the sections; or a boiler of the ordinary vertical type with internal fire-box may rest upon a lower section of fire-box formed as a feed-water tank.

FIG 4

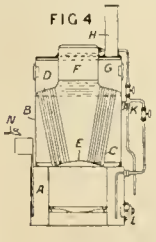
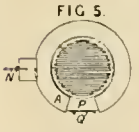


FIG 5.

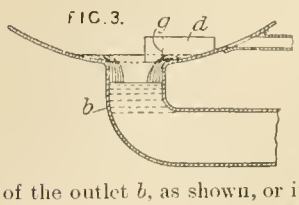


No. 181,647. Steam-condensers.

Weir Limited, G. & J. and Weir of Eastwood, William Douglas, Baron, Holm Foundry, Cathcart, Glasgow. October 14, 1921, *No.* 27264. [*Class* 32.]

A vertical plate is arranged directly above the water outlet of a steam-condenser, with the object of preventing vortex motion in the out-flowing water, and a consequent rise in the water, with risk of its entering the air outlet, which is to be placed as near the water outlet, as possible. The plate *d* may extend outwards from the axis of the outlet *b*, as shown, or it may stop at the edge of the outlet, as indicated by the dotted line *g*, or it may extend across the outlet.

FIG. 3.



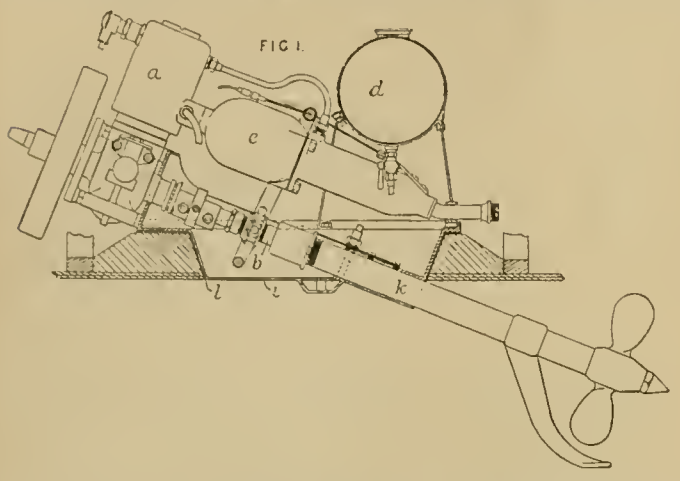
No. 181,959. Propelling Boats.

Saunders, S. E., Padmore House, Whippingham, and Clarkson, A., Columbine Works, East Cowes, both in Isle of Wight. June 8, 1921, *No.* 15851. [*Classes* 113 (ii) *and* 114.]

A detachable propelling-unit carried upon a bed-plate mounted in the hull of the boat, comprises a trough-shaped bed-plate *i* carrying

the motor *a*, a tail-shaft *b*, petrol tank *d*, and a silencer *e*, the motor being mounted on a forward flange and the stern tube *k* on an after flange. The bed-plate is held down by bolts in the slot *l* in the

FIG 1.



bottom of the boat, when the installation is removed, a hatch is put on the slot *l*. In a modification, the bed-plate is mounted on the bottom of the boat and the tail-shaft passes through the stern post.

No. 182,034. Furnaces.

Petersen, K., 4, *Gl. Kongevej, Copenhagen. September* 2, 1921, *No.* 23364. [*Class* 51 (i).]

A furnace grate with a mechanical underfeed stoker is arranged so that the grate elements are adjustable to different inclinations from the stoker trough to the ash-discharge side of the grate, to suit various grades of fuel. Figs. 2 and 3 show applications of the grate to a flue boiler and a water-tube boiler respectively. The grate elements 17 are arranged transversely of the grate and are supported at their inner ends by the edges 19 of the trough 18, and are adapted to turn about the edges 19. The outer ends of the grate elements are supported by a plate 21 engaging rails 31 on the flue bottom, whereby the inclination of the grate may be varied. The left-hand half of Fig. 2 shows the grate in a position for burning highly volatile fuel, while the right-hand half shows the grate in a more inclined position for less volatile fuel. Partitions 25 divide the grate elements 17 into longitudinal passages 26, 27, which have bars 23 on their upper sides. The spaces 24 between the bars 23 are arranged at such an angle that air or steam passing through them tends to move ash towards the troughs 1 at the sides of the grate. Plates 29 resting on flanges 30 at the bottom of the passages 26 regulate the quantity of air passing to different zones of the fire. Steam or water may be passed through the outer zones to disintegrate clinker formed on the bars. The ash-conveyers may be either shafts 2 with screw-blades 3 of increasing pitch and radius, as shown, or continuous helices of increasing pitch, so that equal amounts of ash are removed from all parts of the grate. The angle of the screw-blades 3 may be varied, while the blades are omitted in the tube 6, so that the clinker and ash become tightly packed, forming a seal to prevent air or gases from entering into or escaping from the furnace by the outlet 7. Water for quenching the ashes is supplied through the hollow shaft 2, or by other means, to the trough 1. The shafts 2 are driven through cranks and ratchet-gearing from the stoker driving-shaft. Modifications are described in which the grate surfaces turn on axes at the sides of the furnaces.

FIG. 2.

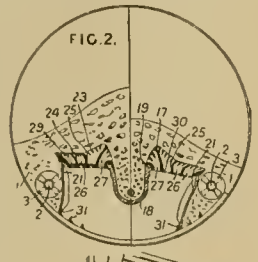
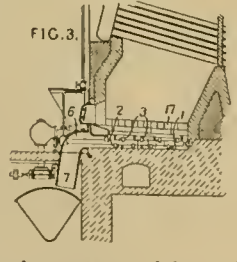


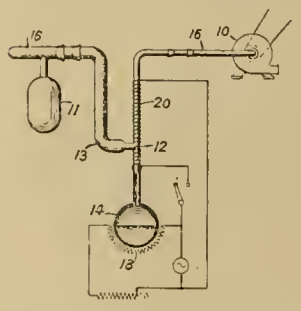
FIG. 3.



No. 182,090. Ejectors.

Western Electric Company Limited, Norfolk House, Victoria Embankment, Westminster.—(Assignees of Houskeeper, W. G.; 111, *West Eleventh Street, New York, U.S.A.) March* 27, 1922, *No.* 8786. *Convention date, June* 20, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 71.]

In order to overcome the objection to mercury-vapour-jet air and gas ejectors, wherein, by reason of the considerable vapour pressure of mercury at room temperatures, a liquid-air-cooled trap between the ejector and the vessel to be exhausted is necessary, substitution is made of the vapour of substances having a vapour-pressure at ordinary temperatures of less than 10^{-6} m.m. of mercury which is the usual pressure within a vacuum tube of the pure electron discharge type, and at higher temperatures a vapour-pressure above 10^{-3} mm. of mercury, which is that usually obtained with rough pumps. When lead, bismuth, or tin are used, the rough pump 10 is operated to reduce the pressure to that value, the metal in a chamber 14 is vaporized by an electric heater 18, and the vapour rising in the pipe 12 exhausts air from the bulb 11 by ejector action, being at the same time maintained at slightly above melting temperature by an electric heater 20, the condensed particles returning by gravity to the vaporizing-chamber. If zinc or cadmium is employed, sublimation temperatures below the melting-point are chosen, the pipe 12 is not heated during exhausting, but subsequently the heater 20 is used to melt the solid zinc, &c., that has condensed on the walls thereof, so that it may return to the vaporizer. Passages 12 and 13 are of pyrex glass and are connected to lead-glass tubing 16 by sleeves of platinum.



IMPORTANT HYDRO-ELECTRIC ORDERS.

It is satisfactory to learn that the enterprise displayed by one of the leading British engineering companies in undertaking a new industry is receiving its reward.

The demand for large-sized water turbines of purely British manufacture induced Vickers Limited to turn their attention to this branch of engineering production, which, as is well known, owes its development largely to Switzerland, where the Alpine snows form a high level storage giving an almost unfailing supply of water throughout the year. Arrangements were accordingly made by Vickers Limited with one of the leading Swiss hydraulic companies to ensure that their designs should embody the accumulated experience, extending over many years, of the best practice in water power installations. The actual manufacture is carried on at the company's well-known works at Barrow-in-Furness, the workmanship being of the high class which is associated with Admiralty standard.

Recently the New Zealand Government placed with Vickers Limited, orders for two Pelton turbines, which are now being erected on site, and followed this up by entrusting them with the manufacture of the two Francis turbines, each of 3,100 h.p., destined to be placed at the Hora Hora power station on the Waikato River. These machines, operating under a 27-ft. head, are of considerable size and will give immediate employment to British labour at a time when it is badly needed.

The highly efficient technical organisation which Vickers have instituted to deal with all hydro-electric matters includes experienced hydraulic engineers, working in close collaboration with the electrical engineering staff of the Metropolitan-Vickers Electrical Company Limited, which firm recently obtained all the orders for the 6,000 K.V.A. generators and the 100,000-volt switchgear for the Mangahao hydro-electric power station in New Zealand.

OFFICIAL NOTICES.

THE Proprietors of the Patent No. 15578 of 1915, for "Method of and Apparatus for Aiming and Launching Automobile Torpedoes" are desirous of entering into arrangements, by way of licence and otherwise, on reasonable terms, for the purpose of exploiting the same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to HASELTINE, LAKE & CO., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

THE Proprietors of Letters Patent No. 18830/1913, relating to "INTERNAL COMBUSTION ENGINES," desire to dispose of their Patent or to grant licences to interested parties on reasonable terms with a view to the adequate working of the Patent in this country. Enquiries to be addressed to CRUIKSHANK & FAIRWEATHER, 65-68, Chancery Lane, London, W.C.2.

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Lord Inchcape celebrated his seventieth birthday on Monday, September 11.

Mr. W. F. D. van Ollefen, ex-Chief Surveyor of *Lloyd's Register* at Rotterdam, died at The Hague, recently, at the age of 71 years.

Mr. William T. Smith, Vice-President of the Harriman Lines, arrived at Plymouth recently in the United American liner *Resolute*.

Sir James Brown Marshall, K.C.B., Chairman and General Manager of J. Samuel White & Co. Limited, shipbuilders and engineers, Cowes, Isle of Wight, Director of Dockyards at the Admiralty from 1906-1917, who died in July last at the age of 69 years, has left estate valued at £26,262.

Lieut.-Col. Sir Philip Wigham Richardson, M.P., and Sir John E. Thornycroft, K.B.E., were among the passengers on the Royal Mail Steam Packet Company's liner *Almanzora*, which left Southampton on September 22 for the Peninsula, Madeira, Brazil and the River Plate.

The death has occurred suddenly at Blyth, of Mr. Walter Wilson Heron, a veteran shipbuilder, at the age of 85 years. He was one of the founders of the Co-operative Shipbuilding Company at Blyth, which specialised in building wooden vessels and owned the first floating dock there.

Mr. John Workman, J.P., of Belfast, who died on September 18 in his eighty-ninth year, was for many years a prominent figure in the shipbuilding and shipping life of the city. With his brother, Mr. Frank Workman, D.L., and Sir George Clark, Bart., he founded the firm of Workman, Clark & Co. Limited, shipbuilders, of which he was a director until that concern passed into the hands of the Northumberland Shipbuilding Company Limited, the chairman of which, Mr. R. A. Workman, is also chairman of Workman, Clark & Co. Limited.

On behalf of the engineering staff of the White Star Line, Mr. Willett Bruce, O.B.E., M.Eng. (Superintendent Engineer), handed a number of valuable gifts to Mr. James Goodier, Junior Assistant Superintendent Engineer of the White Star Line, who has been appointed to the position of Superintendent Engineer at Southampton. These included a roll-top desk, a marble clock and bronze ornaments. Mr. McGowan, speaking on behalf of the senior engineers, declared that the presentation was made as a memento of the real esteem in which Mr. Goodier was held by all, and Mr. T. A. L. Bailey, for the junior engineers, said that every engineer in the employment of the company had a most profound respect for Mr. Goodier. Mr. Willett Bruce remarked that, although he felt sorry to part with Mr. Goodier when he was doing so much to lighten the load on his own shoulders, he felt that, in the company's interest, he must let him go.

Sir John Thornycroft, head of the famous firm of shipbuilders and engineers, on behalf of the company, recently made a presentation of a silver tea service to Mr. R. J. Cook, Machine Shops Superintendent, as a mark of their appreciation of his 50 years' service with John I. Thornycroft & Co. Limited. Though more or less retiring from active and practical work, Mr. Cook's services will still be retained in a consulting capacity. Mr. Cook joined the firm in 1872, when only some 11 men were employed, and the firm's sole establishment was on the Thames at Chiswick. At the height of the war over 6,000 hands were employed by Thornycroft's. In those early days the craft (torpedo-boats) they built were of only about 150 i.h.p. The machinery of some more recent flotilla leaders and destroyers, built under his supervision, exceeded 15,000 s.h.p. per ship. As Sir John Thornycroft said, "His practical skill, mechanical ability, hard work and devotion to duty contributed much to the success of the firm." Hundreds of apprentices have passed under his care, and, in addition to the sound technical and practical training which he helped to give them, the example of his cheery optimism and sterling character could not fail to impress itself upon them.

Captain John A. Bonnyman, M.B.E., who has been appointed General Manager of the Cambrian Dry Docks, Swansea, in succession to Mr. T. Harris, who has retired, is the son of Mr. James A. Bonnyman, M.I.N.A., a member of the North-East Coast Institution of Engineers and Shipbuilders. The new General Manager, who is about 35 years of age, served his apprenticeship as an engineer and ship-repairer with Thomas Diamond & Sons, now Thomas Diamond & Co. Limited, Cardiff. Afterwards he became draughtsman to Blair & Co. Limited, Stockton, and subsequently one of the assistant managers to Smith's Dock Company Limited, South Shields, which appointment he held when the great war broke out. He at once relinquished his post and enlisted as a private in the Northumberland Fusiliers four days after war broke out. Subsequently he secured a commission and later rose to the rank of captain, serving through the Palestine campaign, where he was severely wounded, in the Welsh Regiment and the Royal Flying Corps. In 1919 he was demobilised and returned to Smith's Dock. About 18 months ago he went to Swansea as Works Manager to the Cambrian Dry Docks. He is an Associate Member of the Institution of Naval Architects.

EDITORIAL.

A NOTEWORTHY PRESIDENTIAL ADDRESS.

In every profession and, in no less degree, in every branch of industry, a practical discourse from a man of proved practical experience will always command attention and respect, and if such discourse should happen to synchronise with a period in the history of the development of any line of human endeavour which may be marked by difficulties and problems highly complex, an utterance such as we have indicated becomes clothed with more than usual importance. As President of the Institute of Marine Engineers for the coming year, Sir George Goodwin, through the medium of his Presidential Address, had a unique opportunity of discussing, before a representative gathering of marine engineers, present-day problems which, in point of magnitude and importance, have, perhaps, never been equalled in the annals of the industry. The extent to which the President has availed himself of this opportunity will be readily apparent from a perusal of his address, an abstract of which appears elsewhere in this issue. By a strange and not altogether unhappy coincidence, Sir George's allotted termination of active service as Engineer-in-Chief of the Royal Navy has taken place almost simultaneously with his Presidential election. In its choice of a President, the Institute is to be congratulated, and in bringing to the Chair the record of almost 40 years' continuous service as an Engineer Officer of H.M. Navy, Sir George has paid the Merchant Service, through the Institute, a graceful tribute and has also furnished yet another demonstration of the bond which connects the two maritime Services—a bond which is likely to play an increasing part in the future counsels of the nation's defence.

The remarkable advances made in methods of marine propulsion during the last 40 years were admirably portrayed by the President in a speech rich in reminiscence. From the days of the horizontal engine with compound cylinders, through the period of the triple-expansion engine, locomotive and water-tube boilers and higher speed reciprocating engines to the recent adoption of steam turbines and mechanical reduction gears, the gradual tendency towards the greater appreciation and utilisation of the expansive properties and higher pressures of steam was traced. The corresponding advance in the status, and the improvements in the conditions of service of the engineering *personnel* were recorded as being but right and proper, having regard to the greater attainments demanded from the marine engineer. Discussing the present difficulties and failures associated with the use of double-reduction gears in the Merchant Service, Sir George, while not disposed to under-rate their gravity, believed, in the light of the successful performances obtained with mechanical gears in the Navy, that such failures would be of a transient nature, and that the system would meet with wide adoption. A point which has not, perhaps, hitherto received the prominence which its importance merits was advanced that the sea-going engineer, as distinct from the builder and the steel manufacturer, must arrive at a better appreciation and understanding of the principles underlying the transmission of power by helical gearing, of the action between the teeth and of the movement of the teeth relatively one with the other. In certain cases of failure the material has been thought by some to be responsible and the impression formed by Sir George tends to the view that the suspecting operating engineer, through lack of a knowledge of the principles outlined, has failed to marshal his facts sufficiently satisfactorily to constitute a definite charge. The average marine engineer is more or less conversant with the general mechanical properties of the metals which he uses, but there is a greater need for the proper understanding of physical metallurgy and the changes which a metal may be expected to assume under heat treatment.

Few problems are likely to exercise the consideration of thoughtful engineers to a greater degree than those associated with the internal-combustion engine, and it is suggested that future discussions on this subject may follow radically different lines from those indicated by present-day theories. A deeper conception of the manifold changes which occur during the various stages of the cycle is essential before the virtual limits of present-day development can hope to be substantially extended, and in the preliminary approach to this conception the united endeavour of the engineer, the physicist and chemist may be necessary. Our knowledge of the phenomena attending temperature changes in materials forming the structure of internal-combustion engines, and their influence on the reliability of the machinery for prolonged sea service, must be considerably augmented if the best results are to be achieved. These are but a few of the problems which confront the marine engineer, and it will be necessary for the engineers of this and of future years, individually or collectively, to devote increasing attention to the higher science bearing on their practical work. In the question of training, Sir George believes that the best results have not yet been achieved. A closer link between school education, workshop experience and sea practice is essential, and theory and practice must be brought to march more nearly in unison. The best education and training practicable should be given our young engineers, with due regard to the development of the highest efficiency in their respective spheres.

We are glad that Sir George has given prominence to a few of the more important problems facing marine engineers to-day. His address, while a tribute to the remarkable progress which has been made, is also a timely reminder of the difficulties which lie ahead. By virtue of its inherent merit his address will go to enrich the Transactions of the Institute of Marine Engineers, and will serve as an inspiration in the work of the coming Session.

SHIPBUILDING RESEARCH WORK.

The prosecution of research in any branch of industy has in the past generally been carried out by recognised public institutions. These institutions are usually in receipt of Government subsidies and are very largely supported by contributions from interested firms forming the particular industries. The constitution of the institutions has more or less necessitated the publication of the pure research work carried out by them, and thus valuable professional information is made available to all and sundry without any financial obligation on the part of the receiver. This fact has long been a stumbling block in the way of the whole-hearted support of public industrial research by otherwise enlightened firms, for although many would be perfectly willing to contribute liberally, the fact that meaner firms may reap the same advantages as they themselves, has undoubtedly prevented their doing so. This state of affairs has resulted in most large firms, convinced of the value of research, setting up their own private research stations; and while this policy is possibly immediately justifiable, it is not necessarily conducive to the general furtherance of science as a whole, for in every branch of knowledge co-operation is the foundation of all progress. The aim, therefore, to combine this spirit of co-operation with a policy of secrecy, more or less necessitated by a firm's financial responsibility to its shareholders, has led to the formation of such quasi-public institutions as our British Research Associations. So far as public shipbuilding research is concerned, the National Tank at Teddington is probably our sole centre. The policy of the Teddington tank is to make all pure research public, but of course secrecy is preserved in the case of commercial research carried

out for individual firms. So far as we are aware no organised general research has been undertaken for groups of firms in this country. Such a policy, however, is at present contemplated in Germany in connection with the Hamburg experiment tank. This tank is controlled by a limited liability company, and a further company has been recently formed, styling itself "The Friends and Patrons of the Hamburg Tank," in order to widen the possibilities of this institution. The company has a capital of 2,000,000 marks, which has been subscribed by the principal shipbuilding, shipping and inland navigation companies in Germany. In addition to the initial capital, many firms are to contribute further annual sums towards meeting the cost of the contemplated research. The results of all research, when completed, are to be privately circulated among the shareholders of the company, both in the nature of reports and in lecture form, at the annual general meeting. The Hamburg tank is the largest and possibly the finest equipped of its kind in the world. It is itself, as previously mentioned, controlled by a limited liability company, but liberal financial assistance is accorded to it by the leading German shipbuilders and shipowners. The former have agreed to contribute an annual sum of 7 marks per man employed by them, and the latter, a sum of 20 pfennigs per gross register ton of their vessels. At the general meeting of the company, held in May last, it was reported that contracts amounting to 500,000 marks had been carried out in the previous three months and a similar amount of work was contemplated for the then immediate future. There can be but little doubt that this institution will play a very important part in the rebuilding of Germany's mercantile marine, and the present progressive firms who are making it possible for the tank to further the cause of pure research are placing their money in a sound investment. The funds at present available are to be devoted to the improvement of the construction of the tank and to the prosecution of research on automatic or internally propelled models and also on large propellers of 2·13 ft. diam. The management of the tank has been recently changed. Dr. Gunther Kempf has been made director with Dipl. Ing. Popp as his chief assistant, whilst Herr Oberingenieur Bruckhoff, the former director, is still being retained in a consultative capacity. Dr. Kempf has made several important contributions to the subject of propulsion, and we will look forward with considerable interest to the development of the Hamburg tank under his direction. We trust that a policy of absolute secrecy will not be rigorously observed with regard to all the research undertaken at the tank, for such a policy, were it to be universally adopted, cannot help but finally recoil upon itself.

MARINE ENGINEERING ECONOMIES.

ONE aspect of the present depression in the shipbuilding and marine engineering industries which has recently been given considerable prominence has reference to the very healthy general interest manifested in the affairs of the shipowner. It has doubtless come to the shipowner as something in nature of a surprise to find a mass of statistics advanced, from unexpected quarters, to show why it will be necessary for him to renew or replace his inefficient tonnage. In justice to the shipowner the fact must not be overlooked that in placing new tonnage on service he is not merely concerned with the cost of production, although in this connection it was indicated at the Edinburgh Conference last month that the quotations submitted by home shipbuilders were still in excess of what he is able to pay for new tonnage. A further consideration is the cost of operating his vessels and in this sphere it is the duty of the marine engineer to evolve, by whatever means, such methods or equipment as will contribute towards reduced operating costs. At the meetings of the British Association, held at Hull in the early part of last month, a series of papers read before the Engineering Section dealt with the question of marine engineering economies, with particular reference to economical steam production. Several questions of far-reaching importance, and which are likely to exercise a distinct influence on future progress, were raised in these papers and in the discussions which followed. Among the subjects discussed were, higher steam pressures and temperatures, Scotch and water-tube boilers, coal and oil firing, mechanical stoking at sea, steam and internal-combustion turbines and their associated reduction gearing problems, the progress of Diesel propulsion, the need for more economical methods of burning coal and the possibility of building up home oil fuel resources by the extraction of liquid fuel from coal.

Mr. Spyer, outlining the possible improvements in the economical production of steam, suggests that such are likely to be found in the direction of higher pressures and superheats, waste heat recuperators or economisers, mechanical firing and mechanical draught, and the mechanical handling of coal and its waste products. The turbine and the water-tube boiler are capable of handling the higher pressures and temperatures, of which 250 lb./in.^{2} and 662° Fahr. are quoted as approximate present-day practical limits. Mechanical stokers have undoubted advantages which, as Mr. Spyer has pointed out, are likely to be greater in the unit furnace of the water-tube boiler than in the multiple-furnace Scotch boiler, but experience in marine practice up to the present has shown that the advantages have been outweighed by the disadvantages. The presence of an excess percentage of sulphur in oil fuel has been responsible for the failure of tubes in boilers of the water-tube type, and, as pointed out by Mr. Stromeyer in the discussion, a considerable source of trouble with oil-fired boilers was found in the fusion of the brickwork at high-furnace temperatures.

Considerable interest attaches to the paper read by Mr. James Richardson, B.Sc., dealing with the propelling machinery of future cargo carriers. Mr. Richardson, while indicating the increasing popularity of the Diesel engine, also discussed its limitations. For such powers as 5,500 equivalent steam i.h.p., the twin-screw arrangement of Diesel engines is still necessary and the largest power developed in any single cylinder at sea to-day is 700 b.h.p. Cargo vessels represent almost 90 per cent. of the total tonnage owned in this country, and for these vessels, where the reciprocating engine may be regarded as almost standard, the Diesel engine will claim increasing attention. Any discussion on the Diesel engine cannot be dissociated from the question of the continuity of the oil fuel supply. Particular interest therefore is to be found in the facts presented by Dr. Lander of the Fuel Research Station, Greenwich. The production of liquid fuel from coal may well play a great part in augmenting our future fuel resources, but there would appear to be one or two difficulties in the way of the process on a large scale. These difficulties are, in part, commercial, inasmuch as the process involves the production of considerable quantities of coke and gas for which the present available market is quite inadequate. The progress of the internal-combustion turbine in recent years has been considerable but having regard to the gearing difficulties already encountered with the high-speed steam turbine, and in view of the fact that the internal-combustion turbine is likely to introduce still higher speeds of rotation, Professor F. C. Lea considered that similar, but accentuated gearing troubles would be experienced unless substantial progress were made with improving mechanical reduction gears.

Viewing these papers collectively, one feels that a definite contribution to the practical advancement of marine engineering has been made, and moreover, although the British Association is not primarily a technical body, we believe that, both in their quality and in their practical bearing on the present needs of the industry, these papers have accomplished more than those read before other of our purely technical institutions for some time past.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

Anthracite and the Anthracite Industry. By A. Leonard Summers. London: Sir Isaac Pitman & Sons Limited, Kingsway, W.C.2. 4⅜ in. × 7¼ in. × ½ in. 126 + ix pp. Numerous Illustrations.

In this small book the author has touched on the origin of anthracite, and has given an attractive description of the geography of the anthracite-producing district of South Wales. The greater use of anthracite for all domestic purposes, and the conservation of bituminous coal with its valuable by-products, is urged. The advantages from the public health point of view by smoke abatement, and the absence of atmospheric pollution, are explained convincingly. Anthracite sources, other than that of South Wales, are briefly discussed, and much valuable statistical data relating to coal output and consumption have been incorporated.

Marine Engines. By A. Ritchie Leask. London: Simpkin, Marshall & Co., Limited, 17, Ave Maria Lane, E.C. 4. 8½ in. × 5½ in. × 1¼ in. 424 pp. Numerous illustrations.

As his earlier book on "Triple Expansion Engines and Boilers" had run through five editions, the author decided not merely to issue a revised edition but write an entirely new book. In the introduction the history of the marine steam engine, from the time of Savery, Newcomen and Watt, is traced, and later chapters bring the reader through the period of the reciprocating engine to the direct and geared turbine of the present day. The Diesel engine has not been dealt with, and had the author indicated in the title that the marine steam engine only would be discussed he might have escaped possible criticism on the omission of a type of engine which enjoys an increasingly substantial marine application.

In Chapter VI dealing with "Turbines and Reciprocating Engines" the author claims to show that "the turbine is much less efficient at high pressures than the reciprocating engine" and that "the turbine is also less efficient at the lower or vacuum end where the greatest efficiency was claimed to be." These are views which are not in accord with the generally accepted principles of modern practice.

The book is written in plain, simple language, and no pretence has been made to treat of advanced theory or design, a fact which is likely to commend it to the sea-going engineer, provided he realises its limitations.

Diesel Engines for Land and Marine Work. By A. P. Chalkley, B.Sc. (Lond.), A.M.Inst.C.E. Fifth Edition. 1922. London: Constable & Co. Ltd. 6 in. × 9 in. × 1⅛ in. 330 + xvii pp. Numerous Drawings and Illustrations. Price 21s. net.

Originally published in 1912, this book, which has now reached its fifth edition, may be said to have grown with the steady development of the Diesel engine. In the introductory chapter, written by the late Dr. Diesel as far back as 1911, appear one or two statements which the advance of time has certainly not stripped of their significance. It is pointed out in that introduction that (*a*) the Diesel is not a cheap engine, and that any attempt to manufacture on a cheap basis is not advisable; (*b*) that England is bound, in the face of competition with other countries, to take full advantage of the Diesel engine, and (*c*) that the coal, which appeared to be threatened by the competition of liquid fuels, will, on the contrary, enter into a new and better era of utilisation through the Diesel motor. It is not too much to say that (*a*) and (*b*) are now accepted and accomplished facts, while (*c*) would seem to hold prospect of early realisation.

With the majority of the larger engineering establishments in this country and on the Continent now manufacturing Diesel engines, and with the number of types ever on the increase, we can readily appreciate the effort necessary on the part of an author of a book such as this to prevent his work degenerating into a cumbersome description of the several types. In this effort Mr. Chalkley has not been wholly unsuccessful, and although this edition may be said to differ from its forerunners mainly in respect of the inclusion of a description of the later types of engine which have been developed in recent years, such descriptions embody only the more salient features. The theoretical considerations appearing in the earlier part of the book remain unaltered, as the changes in principle which have developed since the first commercial application of the Diesel engine are regarded as relatively small. Standard four-cycle engines of 3,200 i.h.p., or 6,400 i.h.p. on twin-screws, are now common, and manufacturers of two-cycle opposed piston engines are prepared to build units of 6,000 b.h.p. in four or six cylinders. The possibilities of the two-cycle double-acting engine are also claiming attention, and the 12,000 b.h.p. marine unit is not regarded as a remote likelihood. Although not primarily a book on the design of Diesel engines, it is felt that this important branch of the subject has been dismissed, perhaps rather briefly, in a chapter running to some 30 pages, and in the matter of drawings and illustrations the author has erred rather on the side of generosity. The book is well written, and with the method of treatment, in the main, sound, it is likely to meet with a large sphere of usefulness.

TRADE PUBLICATIONS.

Rotary Pumps.—Stothert & Pitt Limited, Engineers, Bath, have recently published a very attractive catalogue of 48 pages, dealing with the rotary pumps as manufactured by them at Bath. These pumps are of the Feuerheerd type, and are suitable for dealing with viscous or non-viscous fluids. Useful data, and an excellent series of graphs illustrating actual tests carried out with these pumps on heavy Mexican fuel oil, tar, molasses, &c., at the works, is included.

Fire Extinguishers.—An illustrated leaflet has been received from The Pyrene Company Limited, 9, Grosvenor Gardens, S.W.1, describing their new type "M" Conquest extinguisher. This extinguisher is compact and has a capacity of 2 gallons, being of the Soda and Acid type. The Fire Offices Committee have approved this extinguisher for insurance rebate purposes and it has also passed the Board of Trade requirements for the protection of ships. The Pyrene Company have also issued a booklet running to 32 pages, and entitled "Modern Fire-Fighting." Every appliance covered by the title is illustrated and clearly described.

The G.A. System of Ship Construction.—A book extending to 15 pages, and containing several diagrams and plates, has recently been received, describing this system of ship construction. The patentees of the system and joint authors of the book are Mr. D. B. Gebbie, 81, St. Vincent Street, Glasgow, and Prof. T. B. Abell, Liverpool University. It is claimed for the system that cost and weight are reduced, and that construction is facilitated. A special feature of the system has regard to the elimination of the usual longitudinal intercostal girders in the double bottom and the substitution of intercostal bars which are attached to the tank top and shell plating only.

LETTERS TO THE EDITOR.

THE "TYNEMOUNT'S" MACHINERY.

To the Editor of
The Marine Engineer and Naval Architect.

Our attention has been drawn to the article in the August issue of your journal dealing with the progress of electric-ship propulsion. In this article the following remark occurs in regard to the Diesel electric ship *Tynemount*:—

"Unfortunately, the performance of the vessel's propelling machinery on service did not justify the high hopes which the early trials had seemed to warrant. Due regard, however, should be had to the fact, that the Diesel engine of 10 years ago was not by any means the success that it is to-day."

This conveys the impression that the trials of the propelling machinery were satisfactory, that the boat was put into service, and on service troubles were experienced with the Diesel engines. This is quite incorrect. The boat was never put into service, and the engines were not the cause of the trouble, as the identical engines without any alteration were, after removal from the ship, put into service elsewhere and are still working quite satisfactorily.

The engines, both before installation in the ship and after removal, gave their full rated power and the specified overload when tested on the brake, but it was found that a considerably greater power was required than the engines were designed to give or were capable of giving.

The engines were of the same design as many engines supplied previously and since, and which have proved entirely satisfactory over years of arduous service.

For Mirrlees, Bickerton & Day Limited,
Charles Day,
Managing Director.

[We take this opportunity of placing these facts before our readers, but would point out that our remarks as to the unsatisfactory performance of the *Tynemount's* propelling machinery referred to that equipment as a whole and not to the Diesel section.]

TECHNIQUE IN DESIGN.

To the Editor of
The Marine Engineer and Naval Architect.

Your leader in the September issue comes at a very opportune time in shipowning, especially with reference to the first of the two operations marked (*a*).

Line 5 reads "it is equally certain that in the specification of the vessel which will satisfy his requirements the same grasp of fundamental principles is not so evident (as in operation *b*). The ideal shipowner is, of course, one who combines a sound technical training in naval architecture and marine engineering . . . or, alternately, one who employs such a person as his representative. It is not advisable to rely alone on the services of the marine superintendent."

Reference here is evidently made to the consulting marine engineer and naval architect, who, I venture to say, was never more necessary to the shipowner than he is to-day.

The evident forthcoming competition for the world's carrying capacity by Germany will not admit of the limited liability shipowner relying so much on the shipbuilder as was the case in pre-war days. Competition is so keen to secure orders that the shipbuilder is tempted to offer a somewhat shorter and beamier ship, with a possible larger block coefficient for a given deadweight capacity, so that the proportions may be such as to make her unsuitable, with the result that the vessel will not be so easily driven as was expected. The marine engine builder may also put forward a smaller engine to run faster, and with a smaller margin in power in the boilers (recent inquiries show a variation of 25 per cent. in the steaming weight put forward by different builders). The result may be such that a vessel which does the required speed on loaded trial may not be able to maintain a good average speed over the twelve months' service, as well as not being as economical as was expected. This result is due to the ship and engine builders trying to make a profit during such trying times as at present prevail, hence the necessity for employing a consulting engineer whose experience will enable him to advise owners as to the limit which may be gone to, so as to get the best result obtainable with the least outlay of capital.

The case mentioned of "a sister vessel of the same form but lower power and speed," is only one of many which occur under the observation of a consulting engineer—there are many ships whose performances could be improved, especially amongst the class of ship which is fairly bluff, or one fitted with a bronze-bladed propeller, often of faulty design. There is frequently insufficient margin of power in boilers fitted with Howden's forced-draught.

I trust I have not trespassed too much on your valuable space, but I feel that such an important subject could not be passed over without emphasising the contents of your valuable leader.

"Crankshaft."

DUMB BARGE RUDDER DESIGN.

To the Editor of
The Marine Engineer and Naval Architect.

In the article on "Dumb Barge Rudder Design" in your September number the writer has endeavoured to enlighten the builders of river craft in this country with regard to the underlying technique of rudder design. Whether, as your contributor suggests, these builders are unacquainted with the first principles of the construction of such an important detail as a ship's rudder is a matter for conjecture or opinion; but whether the application of Beaufoy's formula as outlined by your contributor, is to make all the difference between satisfactory and unsatisfactory results is a matter upon which no two opinions should exist. The shortcomings and inapplicability of Beaufoy's and Joëssel's work have been often referred to. Probably the researches of Dr. Matthias* constitute and contain the best criticism of the work of these early experimenters in so far as their shortcomings are concerned; and the recent paper of Messrs. Baker and Bottomley, before the Scottish Institution, the most reliable criticism as far as their inapplicability to ships is concerned.†

The *à priori* treatment adopted by your contributor, in basing all scantlings upon the numerical constants involved in the Beaufoy formula renders his ultimate expressions of little quantitative value.

Apart from this fact several other assertions made by your contributor should not be allowed to pass unchallenged.

On page 350 your contributor states that considerable divergence of opinion exists as to the best shape of rudder for, we presume, such craft as barges. To anyone acquainted with the river craft of Germany (the country which easily possesses the greatest number of such craft in the world) there exists no possible doubt that the type of rudder universally adopted is the long rectangular type. The reason for this

* *Schiffbau*, 1911-12.

† See also an article by Mr. A. W. Johns in *Syren and Shipping*, June 29, 1921.

unanimity of type is due to what your contributor considers a common misconception, but what actually is a unique misconception—on your contributor's part. In effect he states that the maximum stream-line velocity only occurs at the barge bottom when an ample (?) depth of water exists between the barge bottom and the canal bed. That this statement is not in accordance with observed facts and experience can be easily shown. A vessel passing along a shallow canal presents a precisely analogous problem to that of the venturi meter. The quantity of water passing (or passed by) the vessel in a given time being constant, any contraction or restriction of the cross section of the canal due to the proximity of the vessel's bottom and the canal bed must necessarily increase the velocity of the ship relative to the water. This increased velocity results in a reduction of the water pressure against the vessel's bottom and thus produces a sinkage of the vessel. The increased velocity also produces an increase in the vessel's frictional resistance. Both these phenomena are well known and invariably occur with vessels moving along a shallow canal at speeds below that of the wave of translation corresponding to the depth of the canal. Thus we see that with shallow canals the maximum stream-line velocity will be in the region of the keel of the vessel and will thus justify the present practice of fitting the well submerged rectangular rudders. Considerable research has been carried out in Germany on this subject, a full bibliography of which can be found in Johow's "Hilfsbuch für den Schiffbau," 1920, page 327 *et seq.*

Your contributor, referring to "bottom drag" in this same connection assumes that this decreases the stream velocity relative to the ship. This is not so, its effect is to decrease the stream velocity relative to the canal bed but not relative to the ship.

Further, in discussing shape of rudder your contributor states "that the surface water also has an appreciable velocity," and on page 352, in discussing wake, he states "that a good average allowance for this is 6 per cent. of the speed of the barge." In Mr. Baker's Scottish paper it is shown that for a vessel of ·78 prismatic coefficient towed without propeller the effect of wake is to reduce the torque on the rudder by 50 per cent. as compared with the open water condition. This reduction corresponds to a 30 per cent. wake. With a barge of say ·95 prismatic coefficient the wake must be considerably greater than 30 per cent. although the increased stream velocity at the keel will tend to reduce the wake appreciably. At the surface where the wake is always greatest (and the relative velocity of rudder and water, least) there is but little doubt that the wake will be well over 60 per cent. and not 6 per cent. as suggested by your contributor. If an average wake value of 60 per cent. over the rudder surface is assumed this will approximately reduce the torque to about 16 per cent. of the open water condition and thus the respective torques for a given rudder behind vessels of ·95 and ·78 prismatic coefficient will be approximately in the ratio of $\frac{\cdot 50}{\cdot 16}$, *i.e.*, 3 to 1. For equal torque the full ship should have a length of rudder at least twice that of the finer ship. This example shows the effect of wake and fullness of form upon the design of barge rudders, a point which your contributor with his 6 per cent. wake allowance seems to have overlooked altogether.

Finally, with regard to the portion of the article dealing with scantlings, your contributor devotes probably more attention to the bending moments coming on the rudder arms than is really practically necessary. The total bending moment in the arms at the centre of the rudder stock must equal the twisting moment in the stock. Hence if the polar section modulus of the stock be divided by the number of arms the requisite maximum section modulus of each arm is at once obtained. The taper of the arm scantling is not governed by considerations of strength to resist bending because the plate itself is sufficiently strong, but should merely taper down linearly to an end scantling which admits of the efficient riveting of the arm to the plate.

The author's treatment throughout this portion of the article being, as previously mentioned, *a priori*, is directly opposed to that invariably adopted by shipbuilders and the classification societies, which method, being *a posteriori* in nature, consists of the application of the principles of strength of materials to the analysis of successful experience. This latter method of rudder design has been successfully adopted by such men as Godron, Schwarz, Prätorius Schöneich, &c., from whose published works much valuable information may be gleaned. At the present stage of knowledge undoubtedly the best method of barge rudder design that a shipbuilder can adopt is to start from the basis of a successful tiller torque and reverse completely your contributor's procedure, thus obtaining practical coefficients which will entirely eliminate such elements of inaccuracy as the constants in the Beaufoy and Joëssel formulæ and the wake percentage. There is no doubt that this method is the one in present use and will perhaps continue to be preferred by individual builders even when such exhaustive work as that at present being carried out by Messrs. Baker and Bottomley makes an *à priori* treatment of the subject possible.

"GOUVERNAIL."

University of Liverpool Engineering Courses.

The prospectus for the Faculty of Engineering, University of Liverpool, for the coming Session which commences this month, has recently been issued by Professor T. B. Abell, O.B.E., M.Eng., R.C.N.C. (Ret.), M.Inst.N.A. One or two changes are embodied in the courses which are likely to prove advantageous to engineers desirous of taking courses in special branches of engineering. Existing courses provide for students who desire to follow mechanical, civil, marine, electrical, and refrigerating engineering, naval architecture and metallurgy. Additional courses include hydraulics, hydrology and the design of hydraulic machinery, and these should prove particularly serviceable to students who intend taking up hydro-electric engineering. Electrical courses will be extended during vacation period to include the design of special types of electrical machinery used in hydro-electric installations.

British Cast-Iron Research Association.

The Director of Research in the monthly circular for September details the matters submitted to the association for investigation. Members have sought advice on problems connected with cupola design and operations, mixtures for heavy cylinders, intricate chilled iron and malleable castings, irregularity in pig irons and scrap, alloy cast irons for castings subject to repeated and continuous heating, sand mixtures for light castings, scaling defects in annealed cast-iron articles, &c. The difficulties arising from defective design, causing shrinkage and porosity cracks, have again been signally prominent in a number of problems submitted by members. The erosion of vessels for heating and melting non-ferrous metals is occupying the serious attention of the Association, and aid has been sought in suggesting suitable mixtures for this service. Work is now proceeding in the more serious researches on motor-car cylinders, moulding sands, refractories, and draws and shrinkages. Interim reports on the progress of these important researches have been prepared for early issue to the members. The Bulletin giving full details of the work done during the first half-year of the Association's activities has been issued to the members during the past month. The replies to the various problems submitted for advice and investigations, together with preliminary reports on the fundamental researches in hand or projected, indicate the earnest endeavour the Association is making to meet the technical and scientific needs of the cast-iron industry.

THE REVIVAL OF CAST IRON.—I.

By "EXAGGEROUS."

To many people it would appear as if the present forms of marine and other engines have progressed about as far as they can progress so long as the materials used in their construction remain as they are to-day. From the geared turbine to the Diesel this would appear to be true, and all that engineers can do is to adjust their designs to compensate for the inefficiencies, or shall we call them the limitations, of the materials as discovered in service and after bitter experience.

In no direction is there a wider field for speculation as to what the future may bring forth than in that of the internal-combustion engine. Here, as in the case of the geared turbine, we have all the elements of progress and of epoch-making developments, but, unfortunately, here also have we got to face the fact that the main material at our command is no better than it used to be and not so good as it might be.

This material is cast-iron. A thousand foundries in the past and a thousand in the present have had and have got men whose knowledge of cast-iron is so profound and so secret that their doings have been watched with bated breath, and as for disputing them, why, nobody would think of such a sacrilege. Such has been the iron-foundry manager and such has been the engineer, his master and employer. Far be it from the writer to throw derision or contempt upon the work of the ironfounder. His job has been to "keep his end up," and he has done it under the greatest possible difficulties and done it remarkably well. Knowing theoretically nothing about metallurgy his little deceptions have met with complete success because those in authority over him knew less still, and because the foundryman as a rule is a jolly smart fellow at his profession, namely, foundrywork.

Hence, what he did not know and (or) could not discover about the swings, he did know, or could discover, about the roundabouts—in other language, he made up for his lack of knowledge about metals by his cleverness at his own trade of founding.

Ancient *versus* Modern.

In the past this system has worked very well indeed. In many works to-day it is still working, and it may be the privilege of the present generation to see some of these works put up their shutters as it was the privilege of past generations to see works, making other things in other trades, close down in face of foreign competition or of superior competition elsewhere. Examples of such events in this country are too common to need mentioning—they come under the heading of British characteristics.

Now, however, the progress of engineering has brought us to the pass that the ingenuity of the foundryman is not all that is wanted, and the casting must not only "look well" and pass such puerile tests as 11 tons tensile and 2,000 lb. transverse (on little test-bars attached to the casting), but the metal of the casting itself will need to possess a very particular grain and very particular properties throughout its mass.

Very pretty, no doubt, will be the many fights that will take place between the old and the new. Level-headed business men will be routed, hard-headed foundrymen will retire hurt, cheap chemists will get cheaper, and so on throughout the field, but progress will make its slow and sure way through the ranks of the unbelievers or inefficients, and they will either be wiped out or join the other side.

The reader may be forgiven for asking what this terrible battle will be about, the answer being that *the cast-iron of to-day is, in many of our largest works, hardly different from the cast-iron of a century ago.* As a matter of fact, little is known about cast-iron because little work has been done upon it. It has been the metal of metals for engineers—cheaply bought, cheaply melted by anyone in any manner in any cupola, very fluid, and with nice little ways of its own which enable foundrymen easily to make a casting of it. Naturally the better the foundryman the better the casting, but not so the metal, for that remains much the same.

It should be perfectly evident to the merest tyro that that sort of thing will not do nowadays and that the engines of to-day want something better than did the engines of the past. Moreover, it would be a great catastrophe if the metal known as cast-iron should gradually disappear and be replaced by something more expensive and probably more difficult to handle. Nor should anyone smile at the suggestion. The earliest engineers had to make almost everything of cast-iron, as forgings, bars and plates of rolled material, low-tensile and high-tensile steels, high-class bronzes, white bearing metals, and so on, had not then been invented, but they have since steadily undermined the position of cast-iron in the engineering world. Yet all this has gone on while little or no work or investigation was done upon the very metal which was being supplanted, and consequently cast-iron, like another famous character, has "never grown up," and live Britishers say, as dead Britishers said, "Well, why should it?"

As everyone knows, or should know, the melting of pig-iron in a cupola furnace is an ancient art, or at any rate, rather ancient to us very modern people. The writer has seen an old book, dated 1813, which describes very little more or less about cupola practice than does another book dated 1913. Both tell you to put your metal in the furnace after having ascertained the correct height for the bed coke, and neither of them tell you how to ascertain it or even if anyone has ever done so; both books also tell you to use about the same volume of air, but neither of them instruct you as to its control and measurement; both books tell you to use the same amount of coke in between the charges of iron, and both make a great point of warning you to be very careful how you do all these things.

Pig-Iron Properties.

Regarding the quality of the pig-iron to be used, each book has some remarkable comments to make upon the grading of pig-iron and the selection of it, after it is purchased by the iron-foundry, and such words as strength, durability, foreign admixture, toughness, hardness, and so forth are liberally sprinkled about and show very plainly that the writer is well up in his subject and knows what he is talking about. It is a little noticeable also that both books, particularly the more modern one, warn any unsuspecting person against being too familiar with chemists and their doings. Dark hints are thrown out that cast-iron is not a thing to meddle with and that only by looking at it for long periods every day during one's lifetime can anybody hope to die possessed of any reliable knowledge as to how to mix pig-irons and how to judge the cast-iron when made. All of which is very disheartening and shows how the engineer has been "cornered" into the position of hardly daring to be master in his own foundry.

As a matter of fact this is mostly camouflage, and if you read a hundred books on cast-iron by practical men you will probably read of a hundred different ways of working a cupola, and if you go into a hundred little jobbing foundries you will find there cupolas serenely giving metal, hot enough and good enough to make some sort of casting or other, without any particular method of working at all. Some person has found, or knocked together, or bought secondhand, something he chose to call a cupola, a similar process has got there a blast machine of unknown and often heartrending power, and anyone who is in on a Tuesday morning feeds the brute with his

own particular ideas of what are correct charges for the day thereof, and, lo and behold, the metal melts and the castings are poured.

In other places the ceremony and its appointments are more impressive, the high chief will consult an ancient and faded *vade mecum*, either in his own writing when a youth or that of his grandfather, the appointments are made by high-class makers, each with his religion and little household gods of his own (the upper row of which are frequently discarded by faithless followers), while the whole show is turned into a working concern by an extra high priest called a cupola man. This person has to be very gently spoken to in case he "chucks up the job," and then where would they be? In this case also does the metal melt and the castings are poured.

It is obvious, therefore, that cast-iron is made in all sorts of ways—*anyway*—varying from the most primitive to the most modern, and the result is not far different in most cases. The sceptic will at once say that he knew all the time that there was nothing in it, but in that he is making the very human error of trusting to his own faulty eyesight. There is a very great deal in it, just as there was a great deal in many other things which apparently contained nothing until science disclosed the contents. We have already mentioned steels, white metals and bronzes, and the advance in those things should be enough to convince the sceptic without calling his attention to what people said about the first railway trains, the first motor cars, the first high-speed steel, and so forth, yet cast-iron is in much the same condition as those first trains and motor cars were in those days. It is full of very great possibilities, it has always been the engineer's best friend even though the engineer has been its worst enemy, perhaps, even probably, it may turn out to be the ugly duckling of the family of engineering materials.

The position is a serious one. Great numbers of engineers in this country to-day are making cast-iron in the more or less comic fashion described above, and many of them will talk utter nonsense about the wonderful recipes of their foundryman, and will gaze through small magnifying glasses at fractures of metal and give weighty opinions about what they see, which is, to tell the honest truth, mighty little at all.

On the other hand, certain firms are working very hard and spending large sums of money upon research and, what is most important, we know that the foreigner, particularly the German, is moving heaven and earth, as the saying goes, to make an advance in the production of cast-iron of superior properties. Perhaps they will fail, perhaps the money will be "wasted," but we think not, and instead, we think that progress will result with benefits to those who are in the running, and loss of prestige and custom to those who lagged behind. It is up to every patriotic British firm to enter into this competition and to establish ways and means of working their foundries on scientific lines—upon such scientific lines as are not a travesty of the term, but as will attract first-class men and encourage first-class achievements.

Average Composition.

Let us examine a little more closely this interesting metal. Cast-iron is iron containing carbon, silicon, phosphorus, sulphur and manganese. Steel is iron, containing the same things but not so much of them. In steel there is also another difference in that *all* its carbon is combined with the iron, whereas in grey cast-iron *part of* the carbon is uncombined and free.

The average composition of scrap (cast-iron), as revealed by the inspection of the average "machinery scrap-heap," is round about: carbon, 3·5 per cent.; silicon, 2 per cent.; phosphorus, 1·2 per cent.; sulphur 0·08 per cent., and manganese, 0·5 per cent. The "secret" mixtures of foundrymen, therefore, produce iron of such compositions that a heterogeneous mixture of their castings gives an average composition much as the above.

The carbon in ordinary cast-iron can vary from about 3 to about 3·7 per cent. without the foundryman being any the wiser; similarly, the silicon can vary between 1·5 and 2·5 per cent.; the phosphorus between 0·7 and 1·5 per cent.; the sulphur between 0·06 and 0·15 per cent., and the manganese between 0·4 and 0·9 per cent. All these very great and important variations may, and do, take place without the foundryman being able to detect them.

The point is that while these variations affect the properties of the solid metal they do not greatly affect its foundry properties and, so long as the foundry properties are all that matter, each works thinks it is making very excellent iron, simply because it is making passably good castings. Also, those castings, as a rule, have been designed with such thick and heavy sections, and the working conditions have been such that it is true to say that almost any composition of cast-iron between the wide limits given above would do for the purpose, and although the metal varied from day to day in any one foundry, those people making or using the castings had no means of finding it out—nor did it matter.

Cast-iron has been cast-iron, no matter whether it was good, bad or indifferent, so long as the casting, as a casting, was presentable.

Let any modern engineer imagine his sentiments if he were told that an important part of an engine could be made of steel, *any* steel, from high carbon to mild, and *any* strength. Yet that is precisely what is daily happening in the case of cast-iron, and modern knowledge and modern requirements are only just beginning to realise and recognise the fact.

Stereotyped Processes.

Of course, this state of ignorance about cast-iron has existed so long and penetrated so deeply that most foundrymen and engineers are hopelessly prejudiced against any change. From grandfather to grandson they are soaked with the idea that they know something about it, and even if they cannot tell you what it is that they know they will point vaguely to "years of practical experience" and to the "success" they have had. It will take a great deal to convince them that their "years of experience" were entirely devoted to making *castings* and included the merest trace of metallurgy; also they will take a lot of convincing that their success did not depend upon their good metal but upon their good *castings*. If you told them that their metal varied all the time and was frequently very poor stuff, they would think you had got a scientific bee in your bonnet and thank their lucky stars that they were not as you.

However that may be, it is a proved fact that cast-iron made in the ordinary foundry is hardly twice alike. No amount of "swanking" on the part of those concerned will alter the fact or improve the metal. The writer uses the term "swanking" to describe those people and those firms who will discourse deeply and profoundly about the "fine metal" they turn out, but who cannot write half a page of horse sense upon cast-iron. For all they have ever known their metal has always been tough and close-grained, and, therefore, in their philosophy, it must be so, and it is waste of time talking about it. As for any rubbishy twaddle about silicon, phosphorus, manganese, eutectics, and so forth, the mere difficulty of pronouncing the words and of finding out what they mean, proves that the whole thing is folly! Put plainly, they will tell you they do not "believe in science," and trust you will take it as a polite hint not to worry them any further about it.

A survey of the situation would be incomplete unless it mentioned those firms who employ a semi-trained analyst at tuppence-hap'ny per annum, and then say, "Oh, science is all right, you *must* have it in these days and we always keep up to the times. See our laboratory." In their case the cure will be found to be rather worse than the disease. They are better off with no science at all than with cheap or inadequate

(*Continued on page* 408.)

MAIN PROPELLING MACHINERY OF U.S.S. "TENNESSEE."*

Some interesting details of the Turbo-Electric Propelling Machinery of the U.S. Battleship "Tennessee," built at the Navy Yard, New York. Propelling Machinery supplied by the Westinghouse Electric & Manufacturing Company, Pittsburg.

The U.S.S. *Tennessee* was authorised by Act of Congress, March 3, 1915, with a limit of cost of hull and machinery of $12,750,000. The *Tennessee* and *California* were the first two vessels authorised which embody the lesson of recent wars, pertaining to watertight integrity, and the use of electric propulsion allowed taking advantage of these lessons to the fullest extent.

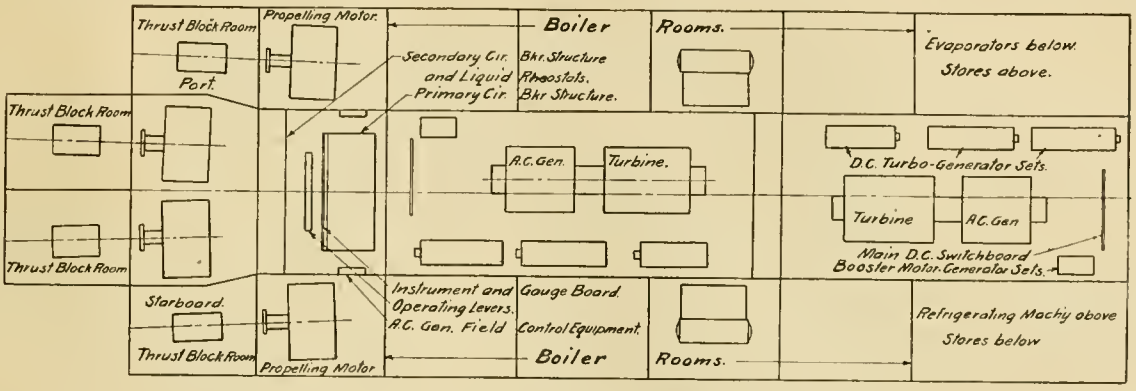
The contracts for the main propelling machinery, its necessary auxiliaries, the six 300-kw. turbo-generating sets and necessary spare parts were let to the Westinghouse Electric & Manufacturing Company, May 12, 1916, for a total cost of $561,217.70.

The keel was laid May 14, 1917, and the hull was launched April 30, 1919, at the Navy Yard, New York. The *Tennessee* was commissioned on June 3, 1920, and since that date has completed successful final machinery and gunnery trials and seen several months' active service in the Fleet, where she has demonstrated her reliability and efficiency.

In profile the *Tennessee* differs materially from that of any previous battleship. She has two smoke stacks, the after stack being surrounded with a structure for four 36-in. searchlights and control towers, the new standard bridge structure, and large control tops fitted on the usual two cage masts, thus giving her a more massive profile than in ships built heretofore. The after cage mast is also surrounded with platforms for four searchlights and gunnery control platforms. All of this can be seen from the illustration on page 381. The cage masts are provided with the usual wireless, signal yards, &c., except that the foremast has no topmast.

Main Propelling Machinery.

The main propelling machinery of the *Tennessee* consists of two turbine-driven alternators, two main condensers, four induction motors, two booster generator sets for excitation supplied with power by any one of six 300-kw. geared turbo-generating sets, motor and steam-driven auxiliaries, main switching equipment, exciter and auxiliary switchboard, ventilating blowers for main motors, control panels and wiring for electric auxiliaries, and necessary wiring for connecting up main generators and motors with the switching equipment.



General Arrangement of Machinery Compartments.

The weight of the main propelling machinery, as listed above, is about 1,700 tons.

The general arrangement of the machinery is shown above. In all firerooms, lower engine rooms, evaporator rooms, and motor rooms Irving subway grating is used instead of floor plating. This has proved very successful. Its advantage over floor plates is that the bilges are open at all times for inspection and also prevents pockets of gas accumulating where oil fuel is used.

Main Turbines.

A section of the main turbine is shown on page 384. The turbine is a Westinghouse double flow impulse reaction type, having one impulse stage with two rows of moving blades and one row of stationary blades. The steam then flows through a series of single flow reaction blading and then a series of double flow reaction blading.

The turbines are designed for 16,000 b.h.p. at 2,075 r.p.m., with 250 lb. steam pressure gauge, 50 deg. superheat and 28·5 in. vacuum.

Referring to the illustration showing the cross section of the turbine, the path of the steam through the turbine can be traced. The exhaust connections to the main condenser are shown at each end, and are bolted to the main condenser,

Hull Data.

	Ft.	in.
Draft designed—		
Forward	29	$11\frac{1}{4}$
Aft	30	$6\frac{3}{4}$
Mean	30	3
Displacement—	Tons.	
On designed draft	32,300	
Per inch on L.W.L.	101·1	
	Ft.	in.
Length between perpendiculars	600	0
Length over all	624	0
Length on L. W. L.	600	0
Beam, extreme	97	$5\frac{3}{4}$
Beam on L. W. L.	97	$5\frac{3}{4}$
Beam, moulded	96	0
At designed draft—	Sq. ft.	
Area immersed midship section	2,875	
Area L. W. L. plane	42,400	
Wetted surface	75,750	
Coefficient of fineness—		
Block	·635	
Midship section	·977	
L.W.L.	·726	
	Tons.	
Fuel oil, 95 per cent. capacity of compartments	4,656	
Reserve feed water, capacity of compartments	588	

Note.—The displacement includes two-thirds full supply of stores, fuel and water; full supply of ammunition.

*Abstract of Paper read by Lieut.-Comdr. C. A. Jones, U.S.N., before the American Society of Naval Engineers, and published in the Journal of that Society.

provision being made for expansion joints to prevent restriction of the end movement of the turbine cylinder caused by expansion or contraction.

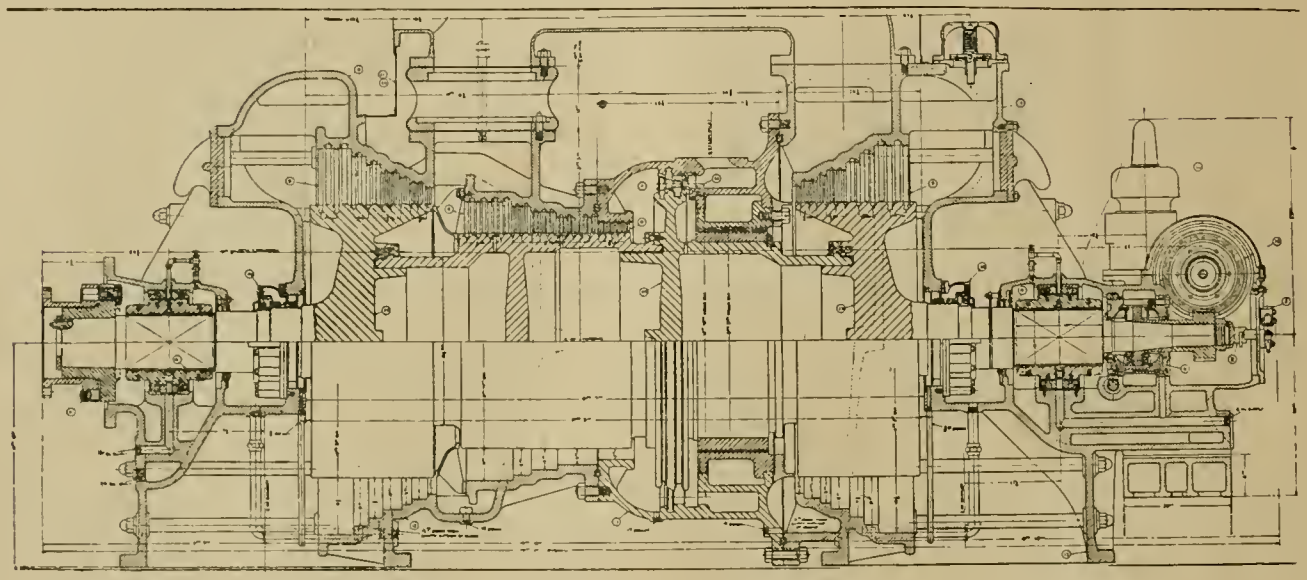
The number of hand nozzle control valves to be opened depends on the load. Their areas are arranged so that by proper use at different standard speeds the maximum pressure can be maintained at the nozzle inlets. The nearer this pressure is kept to the pressure available in the main steam line the better the efficiency obtained.

The steam thrust, due to the single flow reaction blading is partially balanced by a balance piston or dummy. The dummy piston is formed by a forged steel ring shrunk and keyed on the turbine spindle. This ring and the turbine cylinder opposite are fitted with suitably shaped strips of soft brass, having a thin edge which limits the leakage of steam from the high pressure to the low pressure side of the dummy. The remaining thrust is taken by a Kingsbury thrust bearing. The thrust bearing shoes and base rings are supported in a cage. Liners are placed between the cage and its cover so that the working clearance between the babbitted faces of the shoes and the thrust collar can be adjusted. By suitable gearing the cage can be moved axially from a connection on the outside of the thrust bearing pedestal to adjust the endwise clearance. This clearance is set with the turbine cylinder hot and while rotating slowly and should be about $\frac{1}{32}$-in. on the side towards the thrust bearing. A scale at the connection on the thrust bearing pedestal indicates the amount the spindle is moved.

The coupling used for driving the generator permits the generator rotor to move a limited amount in an axial direction in order to obtain flexibility. The type of coupling used is a pin type, coupling sleeves being pressed and keyed on the turbine spindle and generator driving shafts.

The governor-controlled inlet valve will tend to open full almost instantaneously on increased power demand which, under certain circumstances, may prove disastrous by causing the carrying over of water or draining the boilers of all steam, unless some device is used by which the rate of opening can be controlled. Also the total power demand increases about 10 per cent. when the revolutions per minute are kept constant and the ship turns with hard over rudder. There is no advantage in keeping the revolutions per minute constant, but it is of considerable disadvantage in that more boiler power would have to be maintained than required and unless excitation was considerably increased the motors would fall out of step. The power limit device developed takes care of these conditions effectively. It is controlled from the control room by the operator of the speed lever and he may control the rate of opening of the governor-controlled valve and the maximum opening at will. The actual operation is accomplished by a three-point starting and reversing electric controller in the control room, operating a small motor at the turbine which by the use of suitable gearing limits the travel of the floating lever system operated by the governor. The governor is free to close the governor-controlled inlet valve at any time but can only open it as allowed by this stop. The position of this stop is indicated to the operator in the control room by the position indicator and by a system of signal lights.

The turbine is fitted with an emergency trip, set at 10 per cent. above normal full operating speed, which is entirely independent in its operation to the speed governor. In case this trip operates it trips closed the main throttle valve, the 10-in. butterfly valve shutting auxiliary exhaust off the turbine, and exhausts the oil pressure in the governor system, this causing the closing of the governor-controlled inlet valve and the opening of the auxiliary exhaust valve to the turbine exhaust casing. This emergency trip can also be operated from the main control room by a direct mechanical connection.



Longitudinal Section of Main Turbine.

The turbine bearings consist of two cast-iron shells, lined with babbitt, held together by bolts. They are of the self-aligning type and the shells are fitted with four steel keys upon which the bearing rests in the pedestal. These keys have steel liners behind them arranged in combination to permit adjustments of the turbine spindle horizontally or vertically in increments of five one-thousandths of an inch. The bearings are provided by suitable piping for forced lubrication.

The coupling end turbine bearing is carried by the end of the turbine cylinder, which in turn is supported on the sides at the centre line, being secured rigidly to the foundations. The turbine bearing at the thrust end is held by a pedestal part of the cylinder casting. Provision is made at this end for endwise expansion or contraction of the cylinder.

At the thrust end of the turbine shaft in the space between the cylinder and the bearing cover are cut two grooves. By means of a pointer secured to the bearing cover, which is fitted to register with the edge formed by the two grooves, the spindle position is indicated.

A barring over gear is fitted on the coupling between the turbine and generator for rotating the turbine and generator rotor.

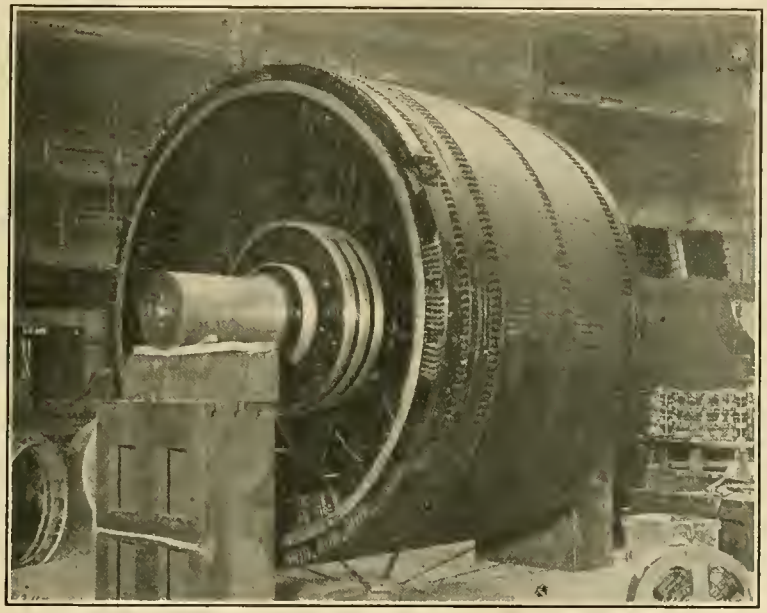
A bridge gauge is furnished for checking the position of the turbine shaft relative to the turbine casing.

Main Generators.

Each generator has a nominal rating of 13,250 k.v.a. They are three-phase, 34·6 cycles, 3,270 volts at 83·4 per cent. power factor, and a maximum rating of 14,850 k.v.a. at 2,195 r.p.m. It is necessary that the field of generators designed for ship propulsion be designed with a good overload margin in order to take care of short time over excitation periods. Over excitation is necessary during starting and reversing in order to supply the necessary torque.

Here, as in all electrical apparatus for marine use, special provision must be made to prevent damage from salt contained in the air. This is accomplished in the main by the use of mica for insulating, only sufficient insulating material of other types being used as found necessary for the proper application of the mica. Special care is taken in applying and baking the several coats of moisture resisting varnish to seal the coils against salt moisture. The windings consist of two conductors per slot, each conductor being made up of a number of strands, individually insulated with mica tape to break up eddy currents.

Ventilation is provided by fans mounted on each end of the rotor. The air is drawn through an opening in the bottom of the end bells from a screened duct below the generator. In order to prevent excessive air noises from the fan being communicated to the engine room, the intake ducts are baffled for changing the direction of air flow. The fan, by building up a high air pressure in the end bells, forces this cooling air through the air-gap and axial ducts in the stator core to the central radial discharge openings and thence to the discharge duct.



Main Propelling Motor, showing Winding Completed.

The rotor is made of one piece steel forging provided with radial slots which carry the coils. Only mica or other fireproof material is used in insulating the rotor windings. Trouble was at first experienced by the end windings shifting position, but this, as demonstrated by severe shop tests and several months' actual service operation, has been overcome by proper blocking. No provision is made for ventilation of the rotor by circulating air in order to prevent the accumulation of salt deposit.

The generator is provided with steam connection for extinguishing fire. The supply valve is of special type so that in case of leakage by the valve the leakage passes to an open drain. There are also provided inlet and outlet dampers to the air supply and exhaust which must be closed when the machine is idle or in case of fire.

Steam heating coils are provided to keep the temperature of the generator slightly above the surrounding air in order to prevent sweating. All joints for the steam connections to the machine are made outside the casing.

The stator windings are provided with six thermo-couples, properly distributed, to measure the hot spot temperatures. The instrument for measuring the temperature is located in the control room.

The rotor is provided with pedestal bearings at each end. The bearing shells are of the self-aligning type, fitted for forced lubrication. Liners are provided for accurately setting the air gap. The pedestal on the collector end is insulated from the foundation to prevent circulating stray field currents.

Illustrations showing the construction of the main generator stator and rotor will be found on pages 381 and 382.

Excitation for the generator is provided from any one of the six 300 k.w. direct current turbo-generating sets installed, three in each engine room. The power required for excitation at full power is about 50 k.w. for each generator. Booster generating sets are provided for varying the excitation.

Main Motors and Liquid Rheostats.

The main motors are three-phase, 24 pole, and have a rating of 7,000 h.p. at 3,270 volts and 170 r.p.m. Up to 15 knots they were designed to operate on 36 poles and have a rating of 2,125 h.p. at 3,250 volts and 118 r.p.m. A maximum rating of 8,375 h.p. at 180 r.p.m. for 4 hours is provided.

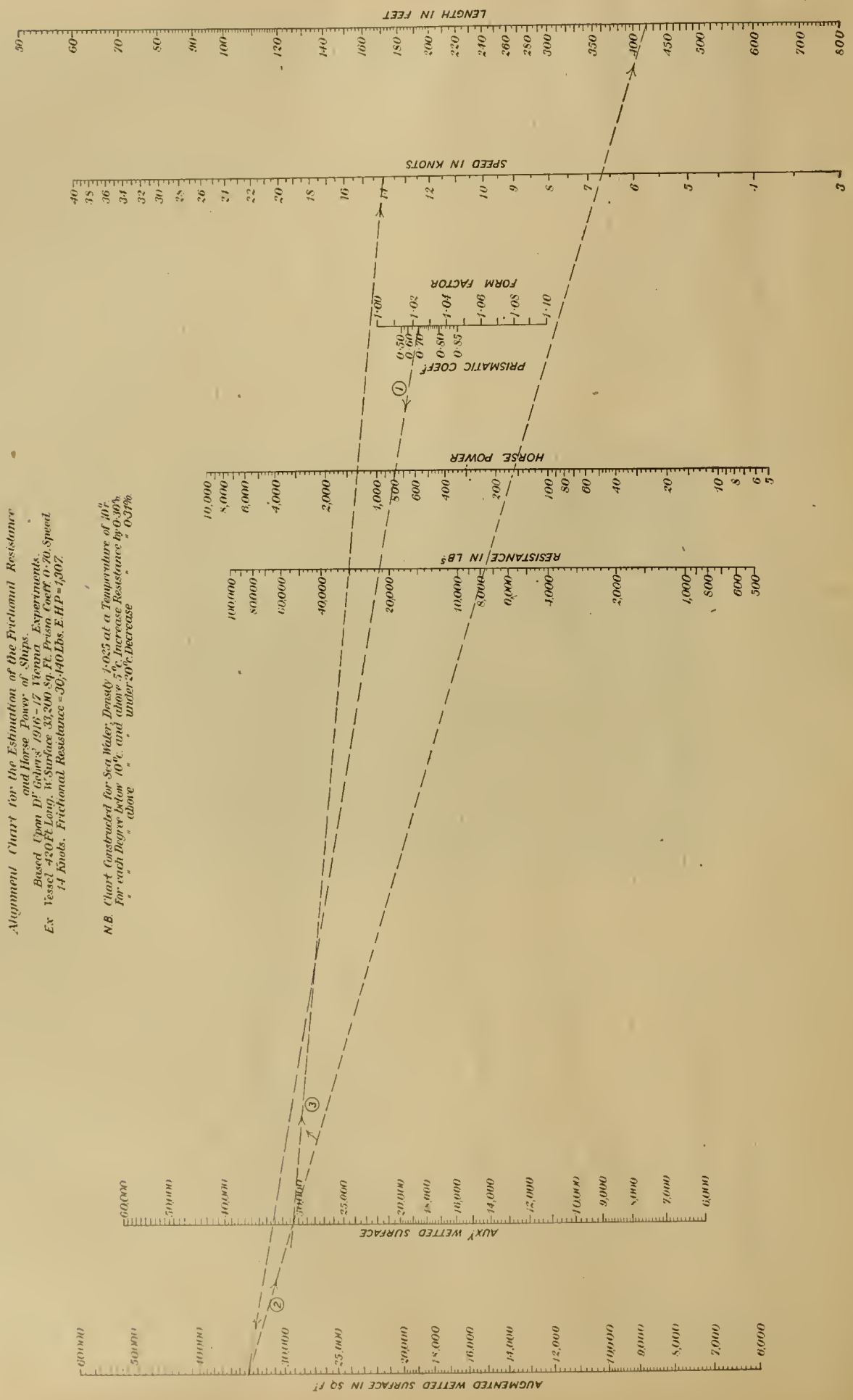
The details of construction are illustrated on pages 381 and 382. They are of the two-bearing bracket type, the rotor being supported by bearings carried in brackets which fit into recesses in the frame and bolted thereto. The frame consists of a single steel casting of skeleton structure. Inwardly projecting ribs are provided with slots for receiving the dovetailed segmental laminations. The supporting feet are cast integral with the frame, and extend across the entire length. Both sides of the laminations are coated with enamel in order effectively to break up the eddy currents. Finger plates and heavy through bolts are used to keep the laminations in place.

The rotor spider is a steel casting of the double arm construction, pressed on and keyed to the shaft. Slots are provided in projecting ribs for receiving the corresponding dovetails of the segmental laminations.

There are two independent windings on the stator, one for 24 pole and one for 36 pole. While this makes a more expensive and heavier construction it has the advantage of simple end connections and provides for putting the machine quickly back in service by cutting out one or more coils in case of local damage. The coils are form wound and placed in straight open slots, having their ends secured to insulated steel supporting rings which are rigidly supported from the stator frame. The coil for the 24-pole winding consists of four copper straps in parallel. The coil for the 36-pole winding consists of a single copper strap. The straight part of the coil is insulated with mica, only sufficient binding material being used to hold the mica, and then ironed in a special machine. This produces insulation of the very highest type. Special care is taken by varnishing and baking to prevent damage by salt moisture.

The rotor is wound with one three-phase winding, permanently connected to three collector rings. By special end connections this winding is adapted for either 24 or 36-pole operation.

(To be continued.)


LENGTH IN FEET
SPEED IN KNOTS
FORM FACTOR
PRISMATIC COEFF
HORSE POWER
RESISTANCE IN LBS
AUX. WETTED SURFACE
AUGMENTED WETTED SURFACE IN SQ FT
Alignment Chart for the Estimation of the Frictional Resistance and Horse-Power of Ships.
Based Upon Dr Gebers' 1916–17 Vienna Experiments.
Ex Vessel 420 Ft Long, W. Surface 33,200 Sq. Ft. Prism Coeff. 0·70. Speed 14 Knots. Frictional Resistance = 30,140 Lbs. E.H.P. = 1,307
N.B Chart Constructed for Sea Water, Density 1·025 at a Temperature of 10°.
For each Degree below 10°c. and above 5°c. Increase Resistance by 0·36%
" " " above " " under 20°c. Decrease " " 0·34%

THE FRICTIONAL RESISTANCE OF SHIPS.

By E. V. TELFER, M.Sc.

Perhaps one of the apparently least satisfactory aspects of the powering of ships by means of model experiments is the Froude assumption that the frictional resistance of the ship is equal to that of an infinitely thin plank of equivalent length, area and speed. This assumption, and the recent assessments of its possible range of error from 5 to 20 per cent., are apt to shake one's faith in the precision of model experiments, but to fortify oneself against this halting between two opinions, one only need recall the many successful vessels which, in service, have proved unquestionable testimonies to the practical utility of the experiment tank. Where any discrepancy does exist in powering it will be generally found to be in the nature of over powering, due possibly either to the cautiousness of the designer or, as is now generally admitted, to the too high assessment of the frictional resistance of vessels obtained by the use of the coefficients drawn up by Mr. R. E. Froude. To concentrate one's attention upon the relative importance of the equivalent plank assumption, let us assume that a tolerance of +1 per cent. in the estimate of a vessel's speed will be permitted.

Permissible Error in Frictional Resistance of Model.

Now let us consider the most correct of possible methods of the utilisation of tank data. The model whose scale ratio is λ has, at the correct corresponding speed, a total resistance r, which is the sum of the correct frictional component f and the wave-making component w, *i.e.*,

$$r = w + f$$

These constituents w and f vary respectively according to the Froude law and the Reynolds or Rayleigh law. It is well known that the wave-making resistance of the ship at the designed speed will be $w\,\lambda^3$, but it is not so well known what the true frictional resistance will be according to the Reynolds law. This law can be expressed as—

$$f = k\,a\,\frac{v^{(2-n)}}{l^n}$$

f being the frictional resistance, k a constant, a the area of the surface, v the speed, l the length of the surface. The value of n has been recently exhaustively examined for smooth planks by Dr. Gebers,* and to it he assigns a value of ·125. Hence we have—

$$f = k\,a\,\frac{v^{1\cdot875}}{l^{\cdot125}}$$

For the ship at the corresponding speed $V = v\sqrt{\lambda}$, this resistance will become—

$$F = k\,A\,\frac{V^{1\cdot875}}{L^{\cdot125}}$$

$$i.e.,\ F = k\,\frac{(a\,\lambda^2)\,(v\sqrt{\lambda})^{1\cdot875}}{(l\,\lambda)^{\cdot125}}$$

$$= k\,\frac{a\,v^{1\cdot875}}{l^{\cdot125}} \times \lambda^{\left(2+\frac{1\cdot875}{2}-\cdot125\right)}$$

$$= f \times \lambda^{2\cdot8125}$$

Hence we can now write that the total resistance of the ship will equal

$$R = w\,\lambda^3 + f\lambda^{2\cdot8125}$$

* "Das Aehnlichkeitsgesetz für den Flächenwiderstand im Wasser geradlining fortbewegter, politierter Platten."—*Schiffbau*, June July, 1921.

The frictional resistance f is here assumed to be the correct value of the model, taking form into account. Now let us assume that the equivalent plank assumption involves an under-estimate equal to $x\,f$. Hence the apportioning of the constituent resistances by the present method would then become—

$$r = (f x + w) + f(1 - x)$$

Therefore the apparent total resistance of the ship at the corresponding speed would be

$$R^1 = (f x + w)\,\lambda^3 + f(1 - x)\,\lambda^{2\cdot8125}$$

$$= w\,\lambda^3 + f\,\lambda^{2\cdot8125} + f x\,(\lambda^3 - \lambda^{2\cdot8125})$$

$$= R + f x\,(\lambda^3 - \lambda^{2\cdot8125})$$

Now let $f = p\,w$

$\therefore \frac{R^1 - R}{R}$, which is the relative error in the resistance due to the equivalent plank assumption reduces to

$$\frac{R^1 - R}{R} = \frac{d\,R}{R} = \frac{p\,w\,x\,(\lambda^3 - \lambda^{2\cdot8125})}{w\,\lambda^3 + p\,w\,\lambda^{2\cdot8125}}$$

i.e., to—

$$\frac{d\,R}{R} = \frac{p\,x\,(\lambda^3 - \lambda^{2\cdot8125})}{\lambda^3 + p\,\lambda^{2\cdot8125}}$$

For analytical purposes R can be conveniently expressed as $R = b.V^n$, and by logarithmic differentiation the following relation is easily established.

$$\frac{d\,R}{R} = n\,\frac{d\,V}{V}$$

This equivalent for $\frac{d\,R}{R}$ can be substituted in the above equation with a result that—

$$\frac{d\,V}{V} = \frac{p\,x\,(\lambda^3 - \lambda^{2\cdot8125})}{n\,(\lambda^3 + p\,\lambda^{2\cdot8125})}$$

But $\frac{d\,V}{V}$ is the speed tolerance of 1 per cent., *i.e.*, equals ·01.

Therefore substituting this value for $\frac{d\,V}{V}$ and solving for x, we have—

$$x = \frac{n}{100\,p} \times \frac{\lambda^3 + p\,\lambda^{2\cdot8125}}{\lambda^3 - \lambda^{2\cdot8125}}$$

$$= \frac{n}{100\,p} \times \frac{\lambda + p\,\lambda^{\cdot8125}}{\lambda - \lambda^{\cdot8125}}$$

Consider now a typical merchant ship case where for a 15 ft. model, λ equals, say, 25, $p = 3$ (*i.e.*, frictional resistance, 75 per cent. of the whole), $n = 3$, the usual assumption for limiting economic speed. Substituting, we have—

$$x = \frac{3}{100 \times 3} \times \frac{25 + 3 \times 25^{\cdot8125}}{25 - 25^{\cdot8125}}$$

$$= \cdot058 \quad \text{or} \quad 5{\cdot}8 \text{ per cent.}$$

Thus we see that an error of almost 6 per cent. can be permitted in the assessment of the frictional resistance of the model and yet the speed has only an error of 1 per cent., and this on what is cryptically termed the safe side. In the case of a vessel whose designed speed is 10 knots, this error in speed is only ·1 knot; and as in this class of vessel divergences of ·2 knot are rarely worried about, an error of 12 per cent. could be tolerated in the estimate of the model's frictional resistance.

Consider now a longer class of vessel where again, for a 15-ft. model, λ equals 50, $p = \frac{1}{2}$, $n = 3$. Substituting, we have—

$$x = \frac{3}{100 \times \frac{1}{2}} \times \frac{50 + \frac{1}{2}\,50^{\cdot 8125}}{50 - 50^{\cdot 8125}}$$

$$= \cdot 135 \quad \text{or} \quad 13 \cdot 5 \text{ per cent.}$$

This vessel would probably have a designed speed of 25 knots, and thus, for an error of ·25 of a knot, an under-estimate of the frictional resistance of the model as much as 13·5 per cent. can be tolerated without one's faith in model experiments being at all called into question. For an error of ·1 knot in this latter case, an error of 5·4 per cent. in the model frictional resistance is admissible. From these two cases we may roughly state that in vessels whose speed and length conform to general practice, an error of from 5 to 6 per cent. in the model friction can be incurred without exceeding the designed speed by one-tenth of a knot.

Thus, as far as experiments with naked models are to be relied upon for the estimation of a vessel's power, the above considerations show that once the Reynolds law is used for the comparison of frictional resistances, it is only necessary to have a first approximation to the true frictional resistance of the model in order to obtain the desired ship speed, with a slight margin whose magnitude is such as is ordinarily considered uncontrollable.

Need for Further Tank Research.

While the above considerations show that the accurate estimation of the model's frictional resistance is not of overwhelming practical importance this fact should not preclude

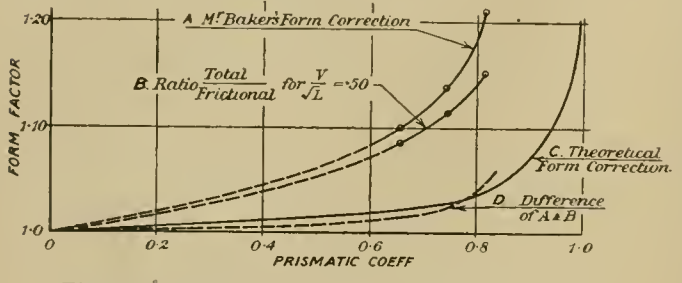


Fig. 1.—Curves showing Results of Mr. Baker's Experiments with Merchant Ship Model, &c.

research being made in our experiment tanks definitely to investigate the effect of form upon frictional resistance. Some work has, of course, been already carried out by Mr. Baker upon this subject. It will be remembered that this consisted of experiments on ship models in air where wave-making was entirely eliminated and also with slow moving ship models in water where wave-making was said by Mr. Baker to be practically negligible. Some figures for the increase of resistance due to form are given by Mr. Baker for a merchant ship model in Table 3 of his work on "Ship Form, Resistance and Screw Propulsion," and these results are plotted on a base of prismatic coefficient in Fig. 1 (curve A) above. Mr. Baker himself points out that these results are likely to be on the high side owing to the impossibility of entirely eliminating wave making, but the apparent confirmation of the water results by the air results places at first sight a certain degree of confidence in the magnitude of the correction. However, the whole validity of the result hinges upon the statement that wave-making was practically absent. In any model experiment there is a definite lower limit to the speed, below which no results are reliable. This limit is, of course, the break-down point of laminar and turbulent flow; and to avoid this phenomenon, Dr. Gebers states that the product of the length and speed of the model should never be less than 5 metres^2 per second. Examining Mr. Baker's experiments from this condition, we see that the product of length and speed in English units should not be less than $5 \times 3 \cdot 28^2$, *i.e.*, 54 ft.^{2} per second. Now, as Mr. Baker's models were 16 ft. long (and even assuming that the whole of their length is concerned in the fluid stability of the friction belt) the lowest practical speed which will yield reliable results is $\frac{54}{16} = 3 \cdot 38$ ft. per second or $3 \cdot 38 \times \frac{3{,}600}{6{,}080}$, *i.e.*, 2 knots. Hence, with a 16-ft. model the smallest speed length ratio which can be confidently relied upon to give reasonably accurate and consistent results is $\frac{2}{\sqrt{16}} = \cdot 50$. Mr. Baker does not state the speed of his models in this connection, but as a $\frac{V}{\sqrt{L}}$ value of ·50 is, from the above argument, the minimum speed length ratio which should be entertained, it is interesting to examine the relative magnitude the frictional and wave-making resistances of an average merchant model at this speed length ratio. Assuming that the models actually run were taken from the Baker methodical series, it is very likely that they had a $\frac{B}{d}$ ratio of 2·25, and a midship section coefficient of ·98. Let us actually suppose that the particulars of the models agree closely with those published in the 1914 Transactions of the Institution of Naval Architects. Assume that the ·66 prismatic model is 67A of that series, the ·75 is 30A, and the ·82 is 68C. These models had values of (M) of 5·9 ft., 5·6 ft., and 5·5 ft., or Taylor fatness ratios of 140, 166 and 174 respectively. Making use of Mr. Lovett's recent Institution of Naval Architect's paper on "The Proportions and Block Coefficients of Merchant Steamers," the frictional resistance of a 16-ft. model of these respective forms will be approximately 2·61, 2·44 and 2·30 lb. per ton displacement. Further, using Mr. Lovett's analysis of the Taylor standard series but modifying the beam draught ratio to correct for the difference between the Taylor standard midship section coefficient of ·926 and the assumed present value of ·98, the values of the wave making resistance become ·242, ·306 and ·409 lb. per ton respectively. The ratio of the wave-making resistance to the total resistance becomes 8·5 per cent., 11·2 per cent. and 15 per cent., and these results are plotted in Fig. 1 (curve B). If it can be safely assumed that no smaller $\frac{V}{\sqrt{L}}$ ratio than ·50 was used by Mr. Baker because the inevitable inconsistency of the results below this limit (and incidentally Mr. Semple in his 1919 Institution of Naval Architect's paper refers to the inconsistency of his own results with a 16·66-ft. model at a $\frac{V}{\sqrt{L}}$ ratio of even ·55), then it seems likely that Mr. Baker's suggested increase for the effect of form on frictional resistance is rather high and more probably is only of the order of 1½ to 5 per cent. over the range of fullness considered.

Independent Analysis.

Some time ago the present writer, from quasi-analytical reasoning somewhat analogous to that involved in the calculation of the Rankine augmented surface, arrived quite independently at this latter order of form correction, but he at once rejected his analysis as untenable in view of Mr. Baker's published figures. However, as the foregoing investigation now somewhat confirms this independent analysis it will be perhaps of interest to consider it. Assume that the actual ship model is replaced by one formed by the prismatic curve of areas, as shown in Fig. 2, and that the fore and aft girth of this prismatic curve is approximately the mean length flowed through by the particles forming the frictional belt. On

this assumption, the mean speed will be increased in the ratio of this girth to the ship's length, but on the other hand, the mean speed will be reduced, because of the longer surface along which the particles are tending to adhere. If the ratio of this girth to the length of the ship be r, then we may assume that in order to take form into account, we should use rV and rL in the ordinary expression for the frictional resistance of a plank, *i.e.*, the resistance for a form of mean girth, r becomes

$$F = kA \frac{(rV)^{1\cdot875}}{(rL)^{\cdot125}}$$

which reduces to

$$F = kA \frac{V^{1\cdot875}}{L^{\cdot125}} \times r^{1\cdot75}$$

$$= F_p \times r^{1\cdot75}$$

where F_p is the frictional resistance of the equivalent plank. Hence, if some simple expression be established for r in terms of the prismatic coefficient, a reasonable form correction may be produced. The method adopted by Dr. Kirk in his well-known wetted surface analysis may be utilised. In Fig. 2, transform the actual prismatic curve into an equivalent trapezoid of equal entrance and run. It can then easily be shown that the length of the entrance is L $(1-\phi)$, and the length of the midship portion is L $(2\phi - 1)$, ϕ being the prismatic coefficient. Assuming that the girth of this trapezoid is equal to that of the prismatic curve, we have, therefore.

$$G = L(2\phi - 1) + 2\sqrt{\frac{B^2\beta^2}{4} + (1-\phi)^2 L^2}$$

$$\therefore \quad \frac{G}{L} = r = (2\phi - 1) + 2\sqrt{\frac{B^2\beta^2}{4L^2} + (1-\phi)^2}$$

where β is the midship section area coefficient.

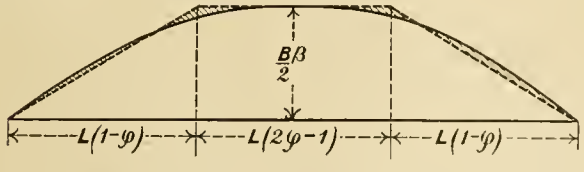


Fig. 2.—Substitution of Prismatic Curve of Areas for Actual Ship Model.

Hence the ratio of the frictional resistance of the ship form to that of its equivalent plank is

$$r^{1\cdot75} = \left[(2\phi - 1) + 2\sqrt{\frac{B^2\beta^2}{4L^2} + (1-\phi)^2}\right]^{1\cdot75}.$$

From this expression, for given values of ϕ and $\frac{B\beta}{L}$, the form correction can be obtained. In the Baker models previously considered the value of $\frac{B\beta}{L}$ was 7·8, hence in this case, after substitution, the expression reduces to

$$r^{1\cdot75} = [(2\phi - 1) + 2\sqrt{\cdot0041 + (1-\phi)^2}]^{1\cdot75}.$$

The following table gives values of the expression over a range of prismatic coefficient :—

Prismatic Coef. ϕ	·50	·60	·70	·80	·90	1·0
$r^{1\cdot75}$	1·014	1·017	1·024	1·035	1·066	1·236

These results are also plotted in Fig. 1 (curve C). If now in this figure, the difference of curves A and B be drawn, it is seen that it should, on the given assumptions, represent the magnitude of the form correction when full allowance has been made for wave making. For the particular case chosen, the actual correction is less than the proposed theoretical correction, but this is due entirely to the value of the speed length ratio ·50 which has been assumed to be that actually used by Mr. Baker. A value intermediate between ·49 and ·50 would bring the two curves into precise agreement, but even in the present case, their difference is not greater than 1 per cent. of the model's total resistance, and is hence within the recognised limits of experimental accuracy.

Whilst the above analysis tends to modify Mr. Baker's results, the fact that these latter were said to be independently confirmed by experiments in air requires careful consideration. With air, although wave making is obviously eliminated, eddy making is by no means a negligible quantity; and further, as both the air and water experiments were necessarily conducted at a $\frac{VL}{\nu}$ value not greatly, if at all, removed from the critical value, it is not too sceptical to suggest that they do not necessarily confirm each other. In order that reliable results may be obtained, there is no possible doubt that the solution of this particular problem must be found with higher speeds, since longer models are hardly practicable. This fact at once precludes Mr. Baker's method, but by use of the method outlined in the earlier part of this article, it ought to be possible to approximate closely to the effect of form on frictional resistance at all speeds. Assume that for ship forms the value of frictional resistance can still be expressed by—

$$f = k^1 a \frac{v^{1\cdot875}}{l^{\cdot125}},$$

then, if the results are known of two similar models, one λ* times the dimensions of the other, at any particular speed of the smaller model, the total resistance r will equal $w + f$, and for the larger model at the corresponding speed the total resistance becomes—

$$R = w\lambda^3 + f\lambda^{2\cdot8125}$$

Thus we have two equations for solving the unknowns w and f in terms of λ, r and R, which are known. Solving these equations, we have—

$$f = \frac{r\lambda^3 - R}{\lambda^3 - \lambda^{2\cdot8125}}$$

The values of f should be calculated for the whole range of speed of the experiment, and if the value of $\frac{f\, l^{\cdot125}}{a v^{1\cdot875}}$, which is of course k^1, is constant, due regard being paid to possible variations of a with change of speed, the validity of the method is established. This k^1 holds good for the particular prismatic coefficient; and finally, the ratio of $\frac{k^1}{k}$ the respective constants of the model and the equivalent plank gives the value of the desired form correction factor. Applying this method over a range of prismatic coefficients, reliable information on the effect of form ought to be obtained. The weak spot in this method lies in assuming that the value of n in the Reynolds law is ·125, the same as for planks. If, however, the results of a third similar model are known, there is no need to make this assumption, for then three equations are available for the solution of the three unknowns, w, f and n. These resulting equations are much more complicated than the foregoing, and provided experiment shows that with the simpler method a constant value of k^1 is obtained, there should be no need to extend the investigation to the more general method.

In order to test this method there should be no need to run further experiments. Sufficient data ought to be already available in our experiment tanks to establish definitely its validity. Mr. Baker mentions on page 54 of his book (1915 edition) that "tests made with three different models at the National Physical Laboratory, all to the same set of lines, but tested at different times, have differed by not more than 1½ per cent." From this statement, provided that the models are of different absolute size (this is not quite clear), the archives of the William Froude Tank already contain sufficient information for the complete solution of the problem. However, until such

* To obtain reliable results $\lambda^3 - \lambda^{2\cdot8125}$ should at least equal unity, *i.e.*, λ should be at least 2.

information becomes available it is suggested that the theoretical values herein obtained should be utilised to modify the plank results. From his experiments, Dr. Gebers deduced the following expression for the frictional resistance of smooth planks in fresh water at a temperature of 10° C :—

$$F = \cdot 193\, A\, \frac{V^{1\cdot 875}}{L^{\cdot 125}},$$

the units being in metre kilograms. This formula gives considerably lower results than given by the Froude coefficients, but as Dr. Gebers' results were carried out in 1916, and with much better instruments than those available to Froude in 1872, and over a range of speeds up to 8 metres per second, as compared with Froude's 3·03 metres per second, and finally, as the Gebers results have been tested and confirmed at intervals, there can be no doubt that they are to be preferred to the Froude. In Fig. 3 we reprint Fig. 13 of Dr. Gebers' *Schiffbau* article in which he compares (in metric

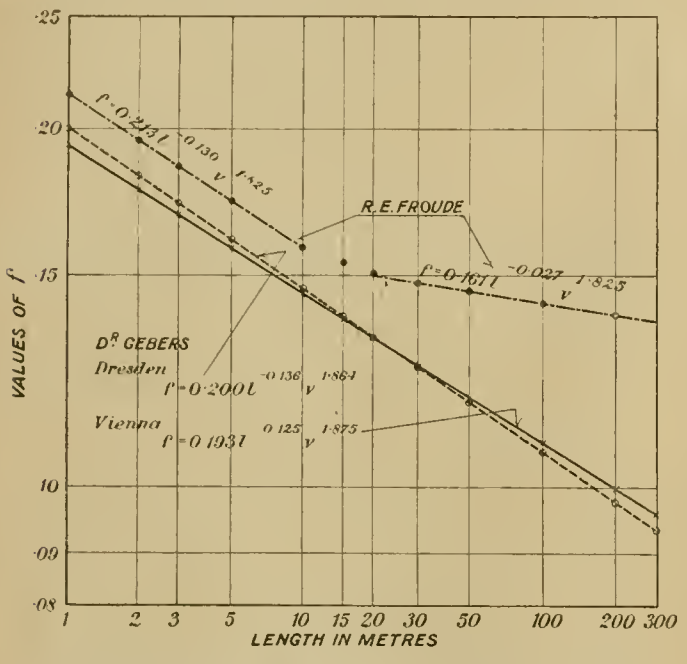


Fig. 3.—Logarithmic Diagram of the Intensity of Frictional Resistance in Fresh Water of Planks of Varying Lengths at Unit Speed, according to R. E. Froude and Dr. F. Gebers.

units) the Froude coefficient with his own present and earlier results. It is there seen that the Froude coefficient is enormously higher than the Gebers, especially for the longer lengths. Mr. Baker* has already commented upon the high value of the Froude coefficient for long lengths, and there can be but little doubt that the Gebers results are to be preferred.* They are in close agreement with McEntees and Zahm's experiments and conform to the Reynolds law. Transforming Dr. Gebers' expression to English units and for salt water of density, 1·025, we have—

$$F = \cdot 01352\, \frac{A\, V^{1\cdot 875}}{L^{\cdot 125}}$$

where F is in lbs., A in square feet, V in knots and L in feet. The corresponding expression for the ship forms becomes—

$$F = \frac{k^1}{k} \times \cdot 01352\, \frac{A\, V^{1\cdot 875}}{L^{\cdot 25}}$$

where $\frac{k^1}{k}$ is the form factor and is a function of the prismatic coefficient and the ratio of beam to length. The numerical values given in Fig. 1 for a $\frac{B\beta}{L}$ value of 7·8 may be used as average values for the particular prismatic coefficient.

Application of Alignment Chart.

On page 386, the above final expression is expressed in alignment chart form. The frictional horse-power is also given on this chart, and it equals, of course,

$$\text{E.H.P.} = \frac{k^1}{k} \times \frac{\cdot 01352}{326} \times \frac{A\, V^{2\cdot 875}}{L^{\cdot 125}}$$

the construction of the chart being such that the frictional resistance and the frictional horse-power are obtained simultaneously. In this chart the form factor is related to the auxiliary surface wetted scale ; and by joining any particular form factor through the auxiliary wetted surface value, the augmented surface value for use with the subsequent manipulation of the chart is obtained. Owing to the uncertainty attached to the precise relation of form factor and prismatic coefficient, the form factor is left as a double scale so that when reliable research is forthcoming from the experiment tanks the correlation scale of prismatic coefficient and form factor may be directly constructed. As it is, this scale is correlated from the suggested theoretical relation plotted in Fig. 1. The subsequent manipulation of the chart is straightforward. Join the augmented surface value to the particular value of length of ship. Through the intersection of this line with the auxiliary surface scale join to the speed. The intersections of this line with the resistance and horse-power scales give their respective values. A numerical example is shown actually worked out on the chart. It is suggested that the use of this chart will prove of greater convenience to those engaged in the powering of ships than the present Froude method of obtaining the frictional component of Ⓒ by means of the somewhat complicated tables of O correction factors in conjunction with ◯.

* N.E.C. Inst., 1915/16.

* The Gebers values do not include any allowance for butts of plating. When a suitable correction is made the Froude and Gebers results will come into closer agreement.

STANDARDISATION OF SHIPS' FITTINGS.

We are advised by the Secretary of the British Engineering Standard Association that two new specifications, one for Bollards and one for Hinges, have been added during the last month to the list of Ships' Fittings Specifications, and that a large number of the Bollard Specification, No. 3005, is already in the hands of the shipbuilders.

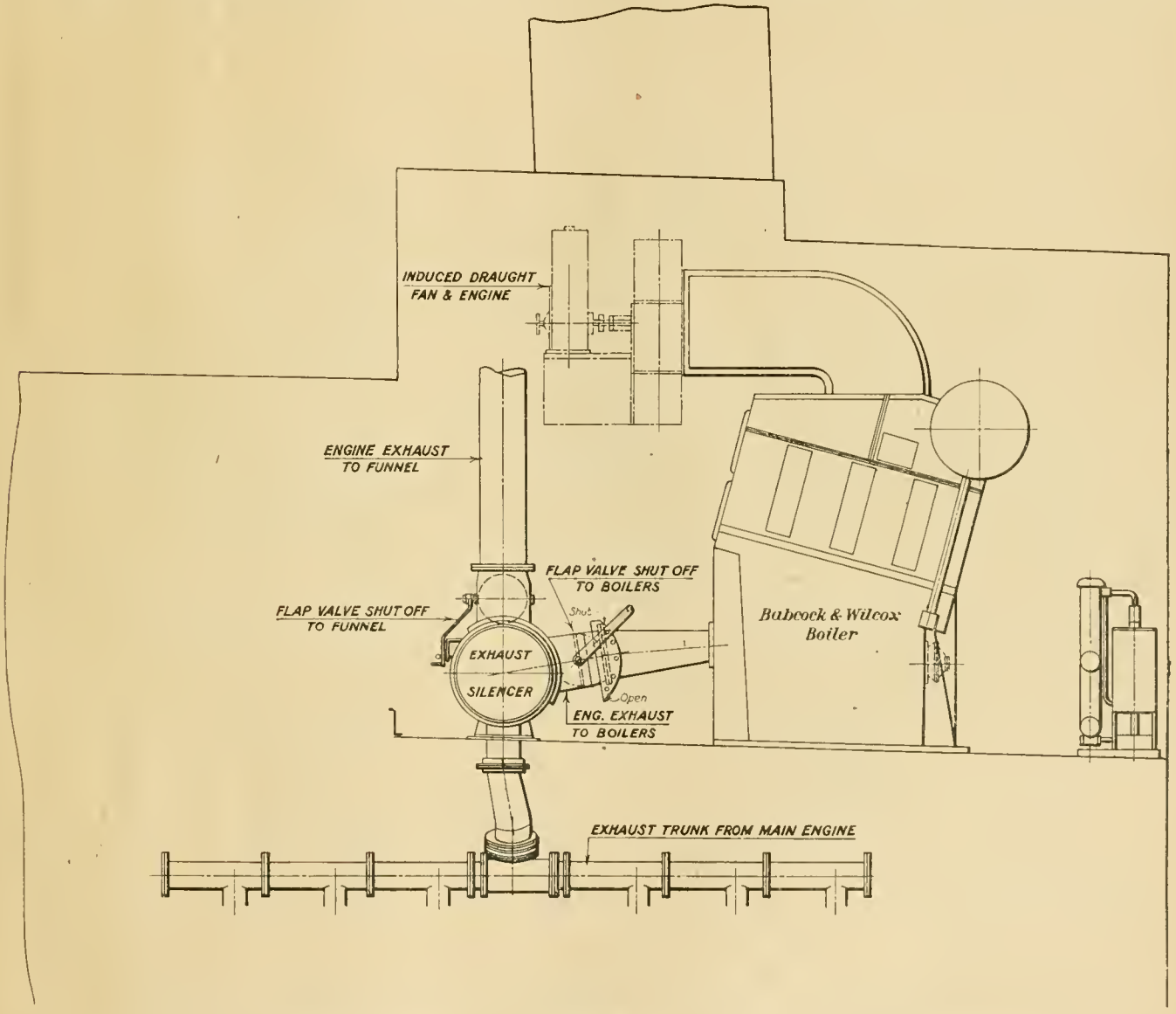
The main design does not differ materially from the usual run of Bollards, but a number of refinements have been incorporated, which, it is considered, will give more efficient fittings in every way. We believe that the use of the British Standard Bollard with the standardised bolting will be of great advantage to shipowners as well as to shipbuilders, inasmuch as these can be readily replaced if necessary. The Specification for Hinges, No. 3004, deals with practically every type of hinge used on ship-board, and not only specifies the size of hinge, but to what purpose each type of hinge should be put. The Specification will, no doubt, prove of immense value to ships' joiners who will be able to order hinges for any part of the ship by referring to the Specification. It is, of course, when it is necessary to replace hinges that the greatest benefit of this Specification will accrue.*

* Copies of the above Specifications may be obtained at the Offices of the Association, 28, Victoria Street, S.W.1., price 1s. 3d., post free.

RECOVERY OF HEAT FROM DIESEL-ENGINE EXHAUST GASES.

Land and Marine Installations Contrasted—System Adopted in Oil-Tank Vessels—Service Conditions.

Although it is generally recognised that the internal-combustion engine returns a lower fuel consumption per unit of power developed than any other engine, there are still one or two subsidiary channels which are being investigated with a view to extracting the maximum heat value from the fuel used. A recent and somewhat outstanding example of one method of recovering what would otherwise be lost heat is to be found in the principle of the Still engine. A further method of utilising waste heat is that adopted in many shore stations throughout the country whereby the heat of the exhaust gas is utilised for steam raising or for water heating.



Athwartship View showing Method of By-passing Exhaust Gases from Main Engines to Boilers.

Diesel Engine Waste Heat.

This waste heat in the exhaust gas of an internal-combustion engine is considerable, and, given a convenient and a suitable arrangement, the temperature of such gas may be regarded as sufficiently high to render its recovery for heating purposes a sound commercial undertaking, particularly in engines of the four-stroke cycle where the gas is not cooled down by scavenge air. It should, of course, be recognised that in shore stations there is usually little space restriction, and in such cases, where the exhaust piping can be arranged with considerable latitude, it is now a common practice to recover as much of the exhaust gas heat as possible for subsidiary purposes, resulting in a substantial increase in overall economy with but little extra first cost. In the case of the motorship, however, conditions are much less favourable inasmuch as space is always at a premium.

Arrangement Described.

Many owners and their superintendents have, in fact, expressed themselves in opposition to schemes for the

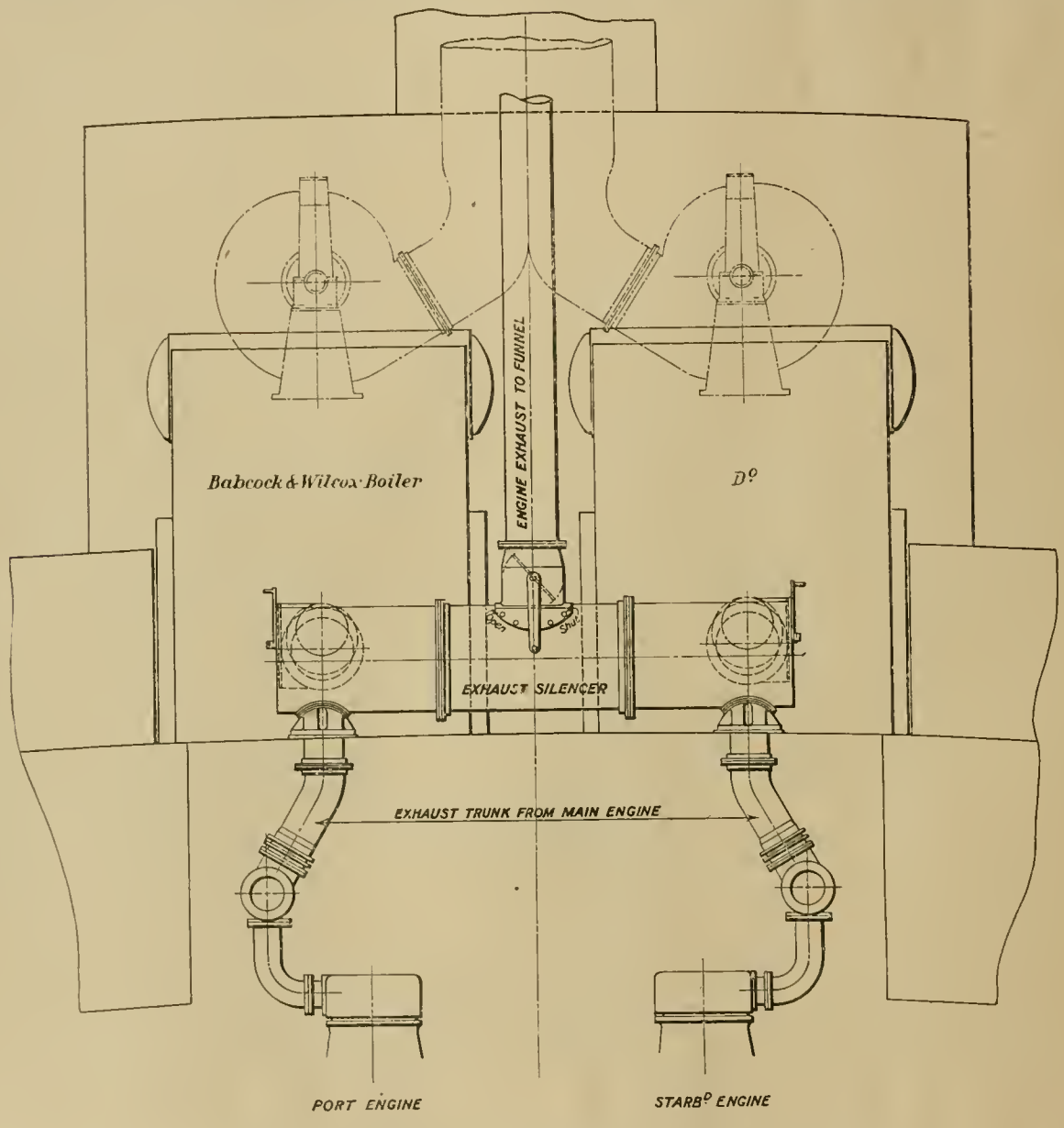
recovery of exhaust heat at sea and this being so it is the more interesting to be able to record actual results from a series of Diesel-engined vessels built and owned in this country.

The vessels in question are the oil tankers *Scottish Standard*, *Scottish Maiden*, *Scottish Minstrel*, and *Scottish Musician*, owned by Tankers Limited, of London, and built by Vickers Limited, of Barrow-in-Furness. These vessels are each of 10,000 tons d.w. and are fitted with twin 6-cylinder 4-stroke engines, of Vickers' make, which develop a collective shaft horse-power of 2,500, giving the vessels a speed of about 10½ knots. The large cargo pumps on these vessels are steam driven, and as the occasional carriage of heavy viscous oils necessitates the provision of ample heating surface, the auxiliary boiler power provided on board is considerable. As will be seen from the drawings which we publish herewith, the boiler equipment consists of two large Babcock & Wilcox water-tube boilers, fitted forward and above the main engines.

Operation and Results.

These boilers are adapted for oil firing under conditions of induced draught, an arrangement which lends itself admirably to a simple means of utilising the exhaust gases as an auxiliary source of heating.

A fairly clear idea of the method adopted may be gathered from the drawing on the previous page. The exhaust gas leaves the main engine at about 750° Fahr. and is caused to pass through lagged uncooled mains to a large silencer which is situate aft of the boilers and lies athwartships. A simple system of deflector valves is fitted, by means of which the exhaust gas can be passed from this silencer direct to the exhaust pipe in the funnel or to either or both of the boilers, as may be desired.



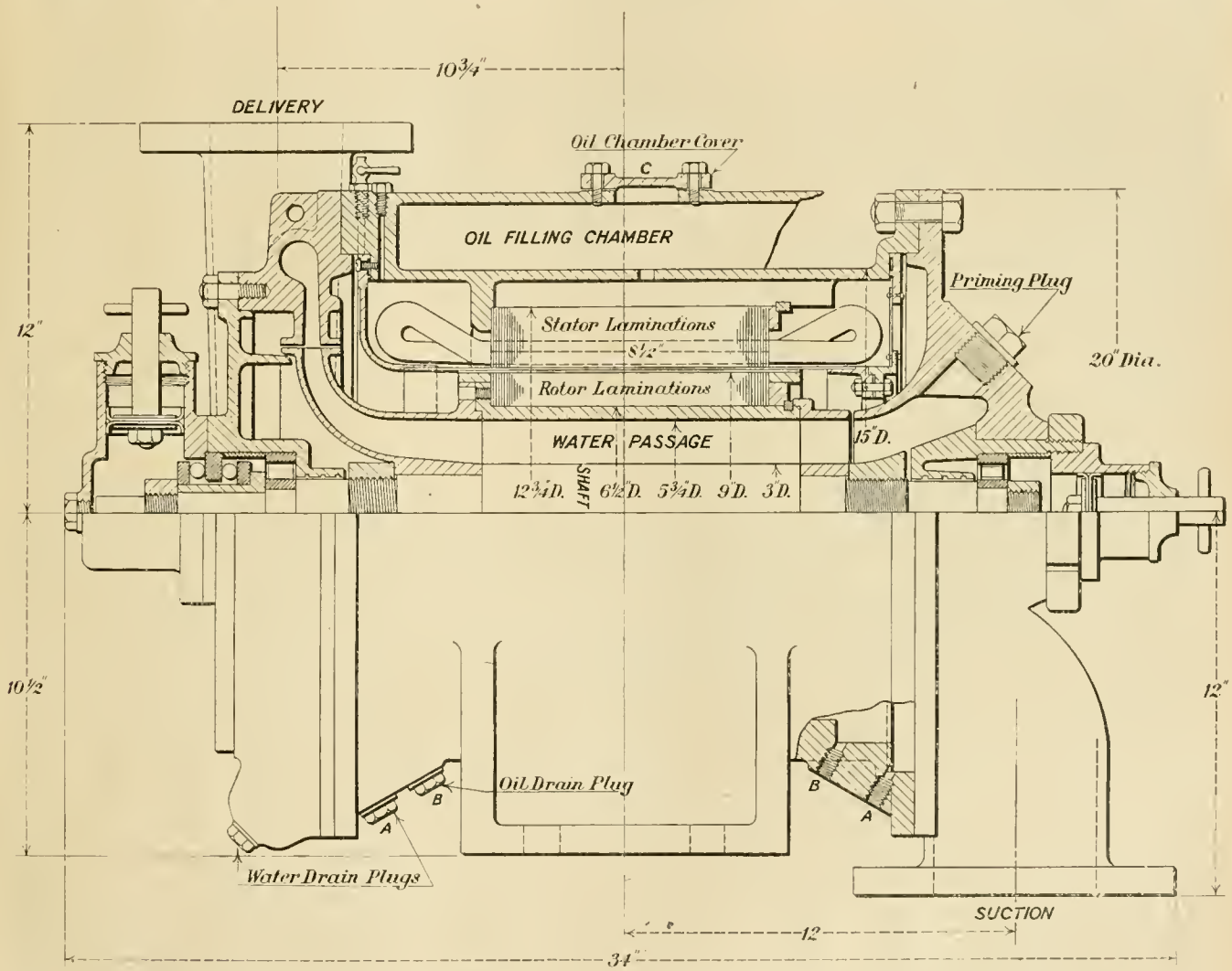
Fore and Aft View showing Arrangement of Piping and Uptake.

The method of working adopted at sea consists of one boiler working under oil-firing conditions, while the other, after having had steam raised by oil firing in the first place, produces steam solely by the heat of the exhaust gases from both main engines. This system has been found to be more efficient than when using both oil fuel and exhaust gas on the one boiler. The results obtained under seagoing conditions have given the owners considerable satisfaction and it is stated that on an average the fuel saved per day by the use of the exhaust gas is no less than 1½ tons.

A NEW ELECTRIC IMMERSIBLE PUMP.

A Compact Electric Pump—Novel Features of Design—Acceptance Trials for Japanese Navy.

The advent of the electric submersible pump some years ago greatly facilitated salvage operations and, indeed, opened up new possibilities which had not previously been contemplated. In the case of a stranded vessel or in the case of a vessel making water while under way the great advantages of being able to lower an electric pump to a point in the proximity of the leak, whether it be in the 'tween decks, in the engine and boiler rooms or in the lower hold, are well known. the patentee, Mr. T. L. Reed Cooper, of Westminster, London. These pumps which are suited for 420 volts, three-phase 60 cycles current, have been purchased for general duty of a varied nature in the naval dockyards of Japan. They are classed as portable pumps and will be utilised either for above-water work or submerged to considerable depths as circumstances may demand. On page 391 we illustrate one of these 4-in. pumps with its associated switchgear, cables,



Reed Cooper's Patent Electric Immersible Pump as Manufactured for the Imperial Japanese Navy.

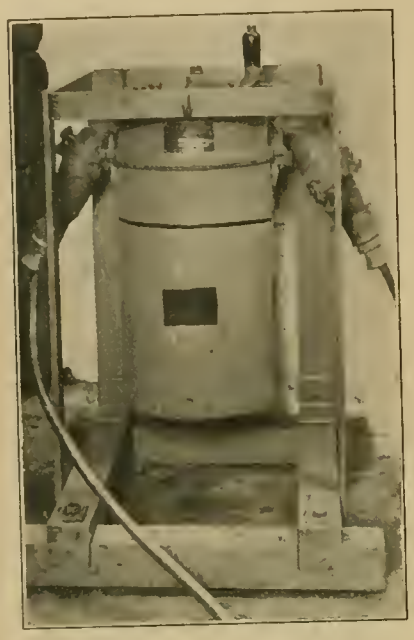
Cumbrous lengths of suction piping are eliminated and the centrifugal or rotary pump, inasmuch as its suction branch is fully submerged, works under conditions which are most favourable to its design. These submersible electric pumps are now comparatively well known and have come to be regarded as a *sine qua non* for almost every salvage undertaking.

We were recently given an opportunity of inspecting an electric rotary pump which embodies several novel features of design and for which several advantages are claimed over existing types. This pump was one of a series built to the order of the Imperial Japanese Navy, the pump, switchgear, &c., having been manufactured to the designs of &c., prior to its despatch to Japan, each of the three main items of the equipment being also shown separately.

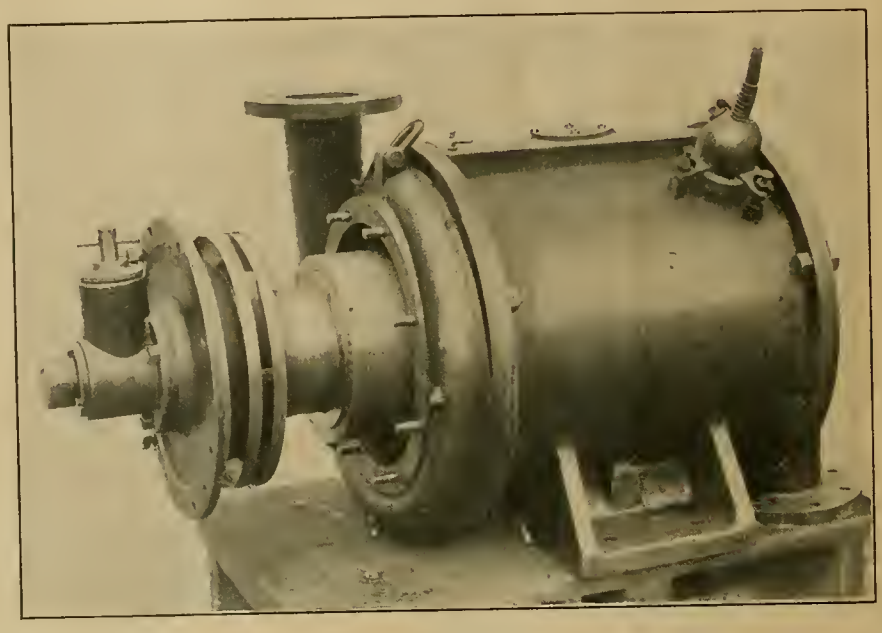
This patent pump comprises a three-phase induction motor having a squirrel cage rotor, to one end of which the pump impeller is attached, while the volute chamber and the delivery connections are formed in the end cover. The suction connection is formed in the other end cover and the water passes in a longitudinal direction through helical passages in the rotor to the impeller. In the photograph which we publish on the next page the impeller and rotor are shown partly withdrawn, and this illustration, together with the sectional drawing above, will convey some indication of the novel design

adopted in these pumps. One of the outstanding features of this design has regard to the method employed for preventing water from reaching the stator windings and laminations. The windings and laminations are contained in a closed annular chamber practically filled with transformer oil. This special design enables high voltages to be used directly in the stator windings and has the additional advantage of readily conducting the heat from the latter to the casing and thence to the water circulating in the inner chamber. As this water passes through the rotor, it will be appreciated that even although the pump should not be working submerged, the temperature of the motor does not rise to the ordinary limits of air-cooled motors. Moreover, the size of the motor driving this pump is actually less than that of an ordinary, open-type, air-cooled motor of equal power.

In the formation of a closed chamber round the stator



Controlling Switch with Portable Stand.



View showing Rotor and Impeller Partly Withdrawn.

General View of Pump, showing Switchgear, Cable and Special Couplings.

windings a special alloy has been adopted which does not impair the electrical efficiency and which is non-corrodible in sea water. This alloy has been chosen after extended research and trials, so that the best electrical results are obtained. The enclosure is in the form of a sheet-metal cylinder in close contact with the stator laminations and surrounding the rotor with the necessary running clearance. It is secured by flanged rings screwed to the yoke at each end, and, to allow for expansion, a flexible steel diaphragm is fitted in one of the flange rings supporting the chamber. An air pocket is also provided in the casting of the yoke to allow expansion of the oil. In the rotor no attempt is made to prevent the water from reaching the laminations since there is no difficulty in insulating the conductors. These conductors take the form of solid copper rods, and the effect of corrosion, if it should occur, is much less serious than is the case with the stator. The water, in fact, has the useful effect of keeping the rotor quite cool. The rotor shaft is carried by a plain roller bearing at the motor end, and in a combined ball thrust and roller bearing at the impeller end. Both bearings, which are of the Hoffmann rustless steel type, are completely enclosed in boxes filled with grease compressed by spring plungers. Through the grease boxes the plunger stems protrude and serve to indicate when the grease supply requires replenishing. The thrust bearing at the impeller end is mounted in an end cover attached to the volute chamber casting by means of studs.

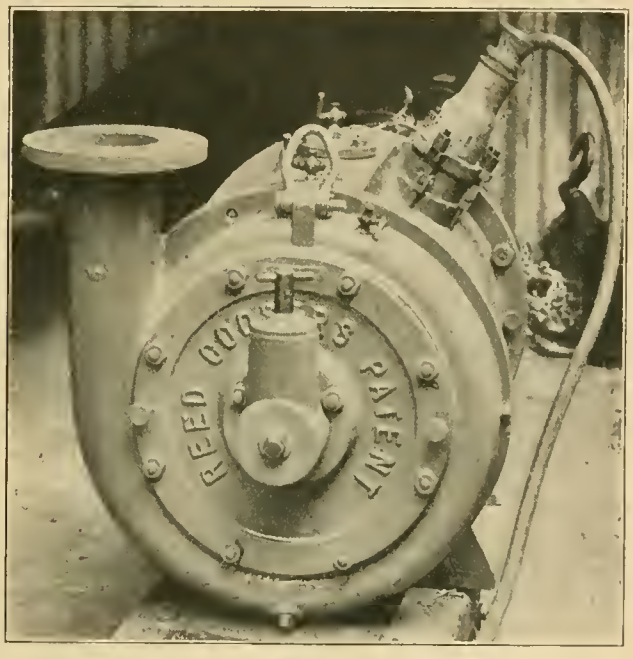
Main Switch Panel.

A feature of considerable practical importance in the design of these pumps has reference to the fact that the whole of the rotating parts, including both bearings, can be withdrawn *en masse* without disturbing the intake and delivery pipe connections. This operation is effected by removing the nuts from the studs holding the delivery end in position and by taking off a ring nut at the motor end. It is thus an extremely simple matter to inspect the rotor and bearings or to clean the water passages when necessary, although, it should be pointed out, the bearings can be examined without taking out the rotor, if desired. It will be seen therefore that all working parts are readily accessible. Specially designed watertight plugs and sockets are provided for connecting the electric mains and the substantial design of these connections will be apparent from the illustrations. Connection is maintained by three swing bolts and a watertight joint is made at two distinct points by means of a special arrangement of rubber rings. These pumps are suitable for any emergency use on board ship as well as for innumerable shore duties, and their high output for small weight and space occupied is likely to make a strong appeal to the shipowner. Some indication of the compact design may be seen from the line drawing on page 393. This pump has a 4-in. discharge and, given the full voltage of 420, will pump approximately 120 tons of water per hour against a static head of 80 ft. The overall length of the pump is less than 3 ft. and the weight when fully charged with oil is only 8 cwt.

Prior to their acceptance of these pumps, the Japanese naval representatives subjected each unit to very exacting tests. The specification called for an output of 100 tons per hour against a head of 80 ft. and this output was substantially exceeded over a six hours' full load trial. The very satisfactory power factor of 0·93 has been obtained with this pump. We publish below data taken at intervals and under conditions of varying heads, and the influence of this variation on the output is readily seen.

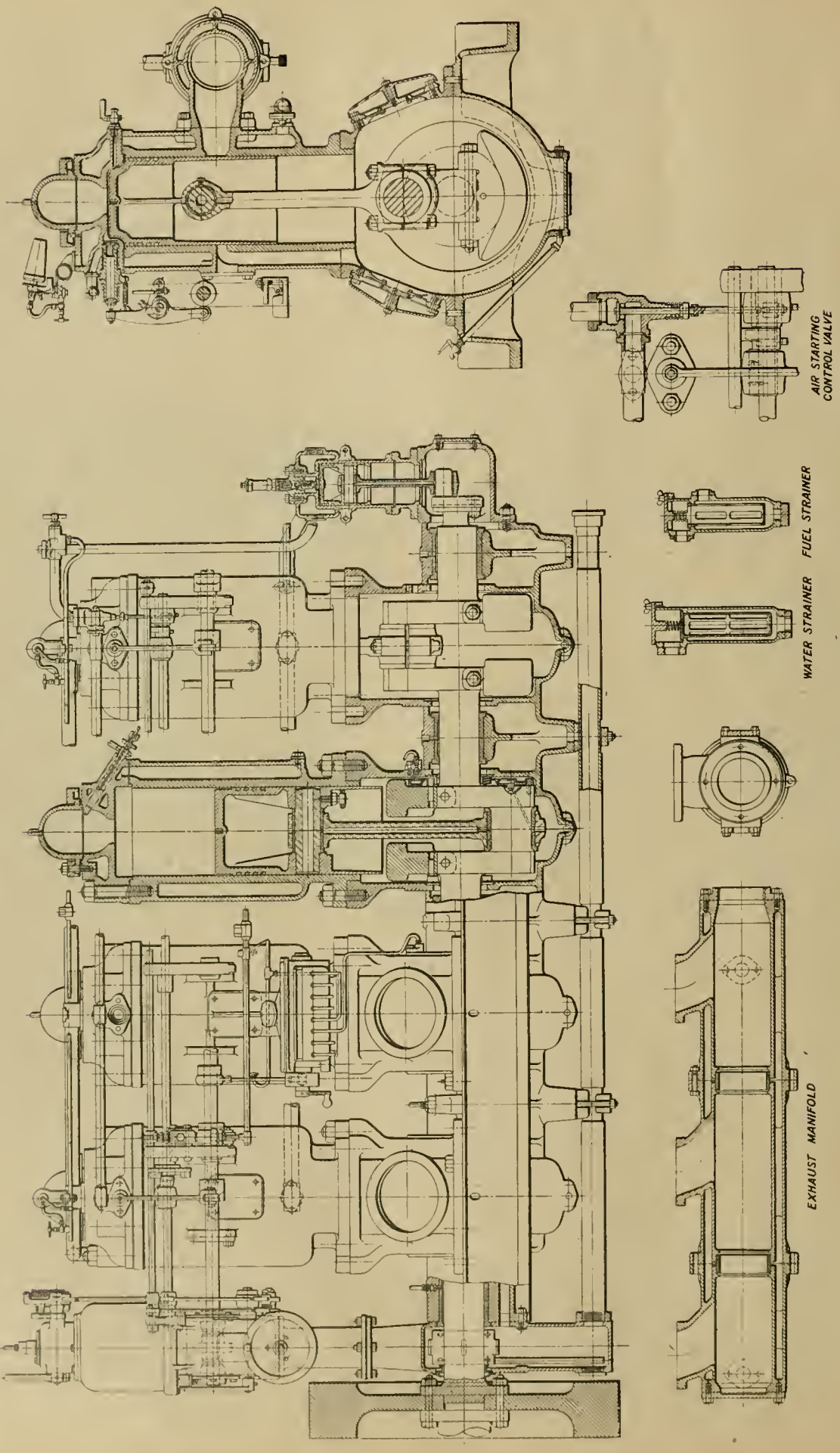
Volts.	Amps.	K.W.	Head in ft.	V. Notch.	G.P.M.	Tons per hour.
415	27	17·2	92·5	7·9	346	92·6
411	29	18·4	86·6	8·3	393	105·0
411	30	19·5	81·0	8·6	430	115·0
415	31	20·2	75·2	9·0	480	128·0
411	33	20·6	63·5	9·5	548	146·6

The output of the pump was measured in accordance with the usual British Admiralty practice, by means of a rectangular V notch and may be regarded as reasonably accurate. From the readings above it will be seen that at no time during the test was the voltage as high as the designed 420. This was due to the supply limitations imposed at the works test house. Yet, with the low voltage of 411, and working against a head of 81 ft., the output was 15 per cent. in excess of the specification. All couplings and insulation were also rigorously tested, and the searching nature of these tests may be evident when it is stated that the entire pump with connecting wires, couplings, &c., were kept wholly submerged for a period of several weeks. At the conclusion of the tests the pump and all its associated switchgear, &c., were completely dismantled and subjected to the closest scrutiny by the naval surveyors. Each part is stated to have been found in excellent condition, and the results of these tests are regarded as being completely satisfactory.



Delivery End of Pump.

A Good Run.—We are informed by Sulzer Bros. that they have received a cable from Hong Kong informing them that the motorship *Handicap*, which is fitted with two Sulzer Diesel marine engines of 1,350 b.h.p. each, has arrived in that port after an uninterrupted run of 43 days from Panama. The engines are in excellent condition and the daily consumption of fuel averaged 9·8 tons.



Sectional Elevation and Constructional Details of Gardner Two-Cycle Semi-Diesel Solid-Injection Marine Engine.

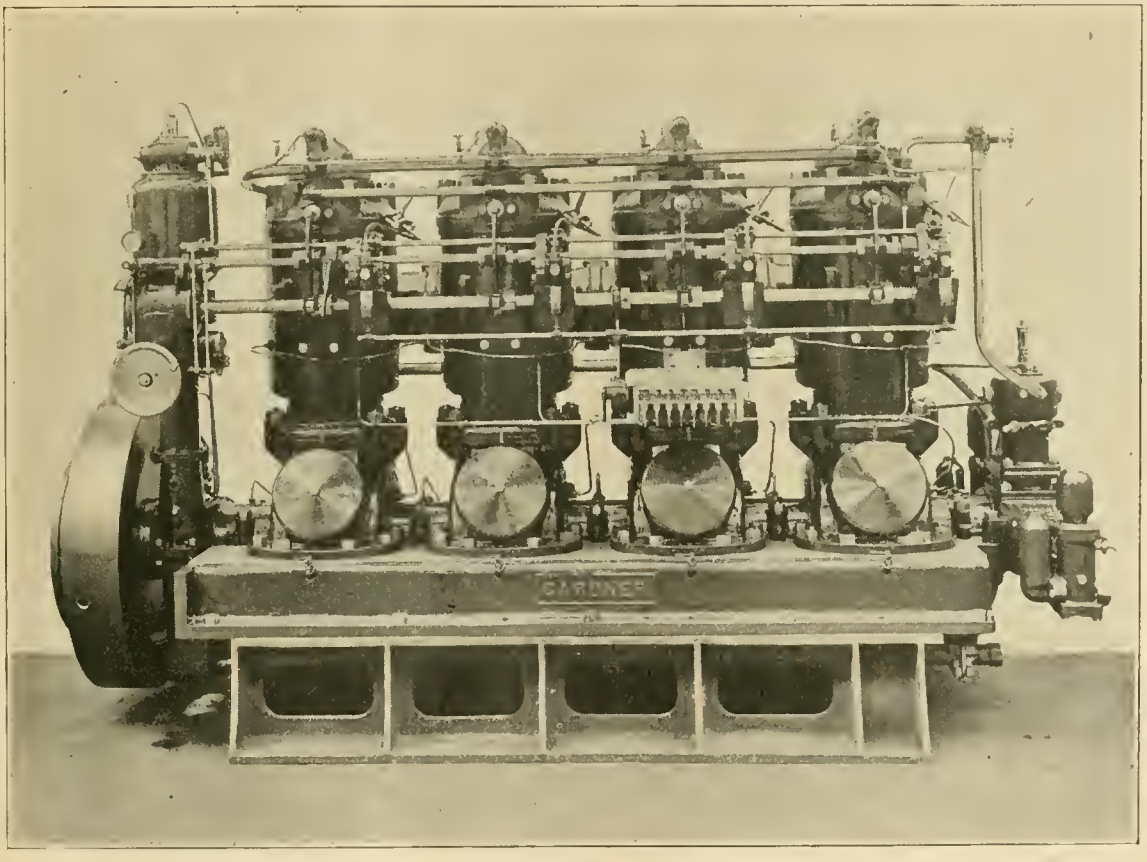
A SEMI-DIESEL ENGINE.

The New Marine Type Solid-Injection Semi-Diesel Engine, manufactured by Norris, Henty and Gardners Ltd., and built in powers from 10½ to 134 B.H.P.

We illustrate below a new type four-cylinder two-cycle solid injection semi-Diesel engine as manufactured by Norris, Henty and Gardners Limited, of Patricroft. Lancs. These engines are designed for marine service and are built in one, two, three or four-cylinder sizes ranging in power from 10½ to 134 b.h.p., and in speed from 550 to 320 r.p.m., the development of higher power engines being in hand. They will run on a wide range of fuels, from heavy residuals to refined paraffin, without any special adjustment, the fuel consumption averaging about 0·5 pint per b.h.p. per hour. Water drip is entirely abolished as these engines will carry their full load without the use of water.

injection and the compressed air starting valves to suit the required direction of rotation.

Patent compressed air and oil spray burners are provided for the initial heating of the bulb. These burners do not require any preliminary heating, but can be started up instantly from cold, and the engine can be put to work within three minutes from lighting the burners, which are not required after the engine has started. The speed can be varied from full to dead slow, and the engine can run at all speeds, either with or without load, without resort to the burners. A separate fuel pump is provided for each cylinder and these pumps are operated from a camshaft along the front of the engine, the



Four-Cylinder 90 B.H.P. Two-Cycle Gardner Heavy Oil Marine Engine.

The drawing, which we publish on the opposite page, gives general details of the construction, the design shown being that of a marine type engine. For this purpose, the rotation of the three and four-cylinder engines is directly reversible by means of compressed air, a small water-cooled single stage air compressor being mounted on the engine to maintain the required air pressure, thus dispensing with a separate mechanical reversing gear. Compressed air is also used for starting, but the two-cylinder engines, not being directly reversible, require a separate reversing gear. The three and four-cylinder engines can be started from any position ; it is not necessary to bar them round into any special position before starting. Starting and reversing are controlled by means of a handwheel which automatically alters the timing of the fuel compressed air starting valves being operated from the same shaft. The fuel-injection valve is a special design of rotable injector, adjustable to suit varying conditions of load. The working temperature of the hot bulbs is 300° C., equal to a black heat, and is controlled by means of the rotable injector. If the bulbs show signs of becoming red hot, the operator can lower the temperature by a slight turn of the rotable jet. A centrifugal governor controls the stroke of the fuel pumps and the timing of the fuel injection while the engine is working.

The lubricating of the main crankshaft bearings is by means of a ram pump, which forces the oil through the main bearings, returning it to an oil sump in the bottom of the crankcase, where it passes through a strainer before being again circulated through the bearings. Cylinders, pistons and

connecting rods are lubricated by a battery of small pumps. One pump is provided for each cylinder, which is lubricated at two points, while another pump is provided for each crank-pin and connecting rod. These oil pumps can be operated by hand to flush the system with oil before starting, or at any time while the engine is working. The lubricating oil consumption of the whole range of these engines is remarkably low, averaging ·006 pints per b.h.p. per hour. Circulating and bilge pumps are fitted at the forward end of the engine, together with the air compressor. These are driven direct from the crankshaft and are an integral part of the engine.

The bottom half of the crankcase is one casting carrying the main bearings, and the top portion of each crankcase is a separate casting, not combined with the cylinder, except on the smallest size engine. Each cylinder is a separate casting with a water jacket of ample capacity, giving easy access to the water space, exhaust and inlet ports for cleaning and scraping when necessary. The cylinder head is a separate casting, forming the lower water-jacketted portion of the hot bulb and carries the fuel-injection valve. The upper unjacketted portion of the bulb is a plain hemispherical casting secured to the cylinder head by a clamp ring. The piston is a plain trunk type with four or more rings. The connecting rods are machined from solid steel forgings, and the big end bearings are of brass, lined with white metal. Crankshafts are machined from solid steel forgings, and are finished bright all over, with balance weights bolted to the webs. The main bearings are of special bronze, and the flywheel is bolted to a flange forged solid with the crankshaft. A water jacketted exhaust manifold receives the exhaust gases. For twin-screw installations these engines are built right- and left-handed.

Engines of this type have recently been fitted in the yachts *Osprey* and *Ara*—the latter being one of the largest in the world. The *Osprey* is fitted with two 4-cylinder 90-b.h.p. Gardner heavy oil engines for propulsion, and the *Ara* with two 3-cylinder 52-b.h.p. engines of the same type which drive dynamos for the supply of current for lighting and all auxiliaries.

"FREE SURFACE" AND ITS EFFECTS.

Oil Fuel Tanks—Effect of Leakages—Free Surface and Metacentric Height.

The problem of the effect of free surface of liquids in tanks is daily becoming more important. With the use of oil-fuel for vessels instead of coal, a far greater number of tanks are liable to have free surfaces, and in consequence it is essential that greater care be exercised to ensure that the tanks are kept pressed up and only those tanks from which consumption is taking place allowed to be slack. In a vessel using coal-fuel there will always be at least one reserve feed-tank slack (that from which make-up feed is being taken), and generally one or two ballast tanks. (It is the usual practice when at sea to keep a pair of water-ballast tanks, one port and one starboard, for correcting the heel of the vessel, as fuel, stores and reserve feed-water are consumed.) For a vessel using oil-fuel there will be, in addition to the above slack tanks, at least one oil-fuel tank with a free surface. These are the minimum numbers of tanks having free surfaces in the respective cases of coal and oil fuelled vessels, but as a general rule there will be a larger number. For example, in vessels with more than one boiler room it is probable that one oil-fuel tank, and perhaps one reserve feed-tank, will be in use for each. In addition to this, leakage from one tank to another, or to an adjoining cofferdam causes free surface, and such leakage need only be of small amount before its effect is apparent. Also loose water allowed to accumulate in the bilges, particularly in the vicinity of the engine and boiler rooms, adds to the unwanted "free" weight in the ship. Extra free surface is added to the above during the process of filling water-ballast tanks.

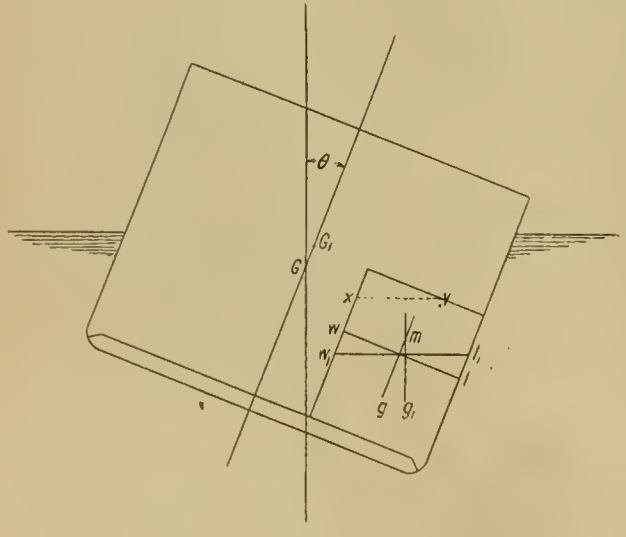


Fig. 1.

Importance of Soundings.

It is thus seen that a constant watch should be kept on the soundings of all the tanks and wells, and all the bilges kept as dry as possible, so that the amount of free surface is always known and can be kept as low as possible. At sea it is the duty of the carpenter to take tank soundings, and it is the general practice to do this and report to the captain of the ship twice daily.

As is well known, the effect of free surface is to reduce the metacentric height of the vessel, and this effect depends solely on the size of the free surface and the total volume of displacement of the vessel, and is independent of the quantity of liquid in the tank and also of the position of the tank in the ship. This can be easily explained. Consider Fig. 1 in which a side tank is shown. g is the centre of gravity of the water in the tank; level of water $= wl$ when vessel is in the upright position. g_1 is the centre of gravity of the water when the vessel is heeled over to an angle θ, the level of water then being w_1l_1. Let the verticals through g and g_1 meet in the point m. Thus, when the vessel is upright the weight of water in the tank acts downwards through g, and when inclined at an angle θ it acts through g_1, or, which is the same thing, through m. Thus the point of application of the weight of water in the tank may be considered virtually to have been raised a distance gm. This distance $gm = \frac{i}{v}$ where i = the moment of inertia of the free surface of the water in the tank about a longitudinal axis through the centre of gravity of that surface, and v is the volume of water in the tank. This formula is similar to the well-known $BM = \frac{I}{V}$ formula for ships. Then if V be the total volume of displacement, including v, and supposing

that the raising of the point of application of v from g to m causes G to be raised to G_1 we have :—

$$V \times GG_1 = v \times gm = v \times \frac{i}{v} = i$$

Thus $GG_1 = \frac{i}{V}$,

and this is the amount by which the metacentric height is reduced. If the ratio of the density of the liquid in the tank to that of the water in which the vessel is floating be expressed as e, this reduction, of course, becomes $\frac{ei}{V}$.

General Effect of Free Surface.

The general effect, therefore, of free surface is to reduce the metacentric height. This method, however, is only of value when considering the upright condition of the vessel, or at the most, for a very few degrees of inclination. This is so on account of the varying nature of the free surface as the vessel inclines. For instance, if the water tank should be almost full, and assuming the tank to be 20 ft. wide, it only needs a very small inclination to cause the water surface to cut the top corner of the tank. For any further inclination the water surface moves inwards, as shown by the dotted line xy (Fig. 1), and the upsetting moment is considerably reduced. It is also apparent from the line xy that the i of the surface is much smaller than when the vessel is upright.

It is, therefore, not correct to make the usual $GG_1 \sin \theta$ adjustment on the stability curves and imagine that the resulting curve gives the new stability curve of the ship, with free surface.

Owing to the possibility of these reductions in metacentric height—and these reductions assume abnormal proportions in many oil-fuel ships—it is frequently necessary to obtain a fairly accurate estimate of what will take place due to the effect of free surface. Some vessels of recent years become very tender with slack tanks, and the need for accuracy is thus apparent. The method always used by the author was formulated on the occasion of requiring accurate results from an inclining experiment, the experiment having been carried out with tanks almost, but not quite full. By way of interest it may be noted here how annoying it is to try and conduct an inclining experiment on a ship with slack-oil tanks. It is very easy to say that the free surfaces can be allowed for afterwards, but the difficulty is in obtaining any consistent reading during the experiment. When free surfaces exist, the pendulums seem to move about almost without reason, unless the vessel has a fairly large metacentric height. The method consists in constructing two sets of cross-curves, one for the ship and the other for the tank. Referring to Fig. 2, let G be the centre of gravity of the vessel, including the water v in the tank, in the upright position, and g the centre of gravity of the water. Suppose the vessel heeled by external agency, wind, &c. to an angle θ, as shown, the point g will move outwards to g_1, and in consequence G will move to G_1. Firstly, using the integrator, with G as axis, find the actual position of g. This is ascertained by Gh and hg, the vertical and horizontal distances from G. Then, for the inclination θ the point g is at a distance lg from the new vertical, through G.

$$\begin{aligned} &\text{Now } hK + lg = hg \cos \theta. \\ &\text{Also } hK = Gh \sin \theta. \\ &\therefore\ lg = hg \cos \theta - Gh \sin \theta. \end{aligned}$$

The centre of gravity of the water in the tank has, however, moved to g_1 and the distance of g_1 from the new vertical through G is $l_1 g_1$. Thus for the angle θ the centre of gravity of the water in the tank has moved a distance $l_1 g_1 - lg$, horizontally in figure. This distance $l_1 g_1$ is also determined by the integrator. Actually, for a series of inclinations, the distances $l_1 g_1$ are determined for various capacities in the tank and cross-curves are drawn so as to permit reading off the correct $l_1 g_1$ for the same quantity of water in the tank as when upright.

The corresponding shift of G to G_1 horizontally in Fig. 2 is thus :—

$$\frac{v\,(l_1 g_1 - lg)}{V}$$

If B_1 is the position of the centre of buoyancy of the vessel in the inclined position, then, for the case shown, GZ (the righting arm) is greater than GG_1, and the vessel will return to the upright, *i.e.*, there is still a positive metacentric height. If, however, for the angle θ, GG_1 is greater than GZ there will be an upsetting couple to incline the vessel still further, and the angle of inclination will increase until such time as B_1 falls directly under G_1. G_1, it should be noted, is continually changing as the angle of inclination changes. This is the case in which the loss in metacentric height, due to the free surface in the upright condition, is greater than the original value, thus resulting in a negative GM.

It may come as a surprise to some to realise how great this effect of free surface is in actual cases. For example, take a vessel 400 ft. long and 52 ft. beam, floating with a displacement of 10,000 tons, and having a positive metacentric height of 1·5 ft. before allowance has been made for free surface.

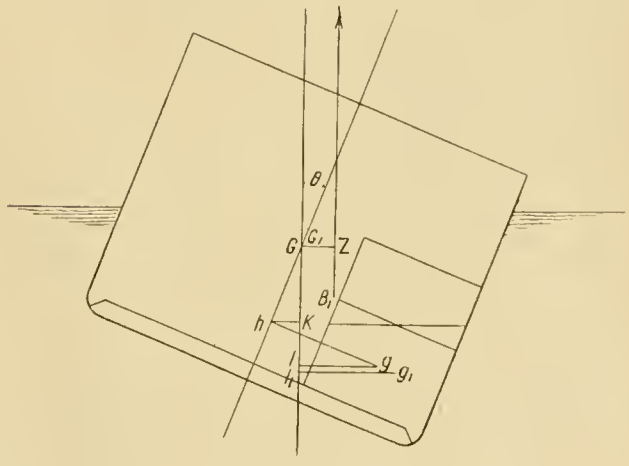


Fig. 2.

If this vessel has four double-bottom tanks slack, two port and two starboard, each 45 ft. long and 24 ft. broad, and also a slack deep tank 35 ft. long and 42 ft. broad, the loss in metacentric height due to free surface will be about 1·2 ft. Treating the tanks as having rectangular surfaces, the moment of inertia of each double-bottom tank, about an axis through the centre of gravity of the free surface, is

$$\frac{45 \times 24^3}{12},$$

and for the deep tank,

$$\frac{35 \times 42^3}{12}.$$

And as there are four bottom tanks slack, the total moment of inertia of the free surfaces is

$$\begin{aligned} &4\left(\frac{45 \times 24^3}{12}\right) + \frac{35 \times 42^3}{12} \\ &= 207{,}000 + 216{,}000. \\ &= 423{,}000 \text{ (ft.)}^4 \text{ units.} \end{aligned}$$

The displacement = 10,000 tons = 350,000 cub. ft. $\therefore$ loss of metacentric height in the upright position

$$= \frac{i}{V} = \frac{423{,}000}{350{,}000} = 1{\cdot}2 \text{ ft.}$$

It is seen from the above how easy it is by means of slack tanks to reduce the stability of a vessel to a very unsafe margin.

Of course it is not uncommon for vessels to be floating with a negative metacentric height and lying over a few degrees to port or starboard—anything up to 5 deg. is common enough. However, such a vessel is unseaworthy, and the captain would be much more at ease if the vessel were upright. Again, if a gust of wind lifted her from her inclined stable position to the upright she would simply fall over to the other side and remain there until she was thrown back again. The steering qualities of a vessel in this condition may also become sadly impaired.

It may be stated here that structural damage has often been suffered by vessels owing to slack tanks, and masses of water being thrown from side to side as the vessel rolls, and fore and aft as she pitches.

SIR GEORGE GOODWIN'S PRESIDENTIAL ADDRESS.*

Forty Years' Progress Reviewed—Future of Mechanical Reduction Gears and the Diesel Engine—Importance of Training.

No greater pleasure can come to a man at the end of his career than to be elected President of the Institute bearing the name of his profession and devoted to its interests. I, therefore, appreciate very highly the compliment you have paid me by electing me as your President for the current year, especially as that esteemed honour came to me just as I had completed my service as an Engineer Officer of the Royal Navy, continuous service lasting nearly forty years. If, as President, I can during my term of office assist in your endeavours for the betterment of Marine Engineering and the Marine Engineer, I shall be pleased to do so and thereby indicate, in some measnre, my gratitude.

The changes that have taken place during the period of my service may properly be described as wonderful; those changes have appeared in every direction, and most of them, it is pleasing to say, have been highly beneficial and useful. To mention a few of the many instances, the conditions of living, public health, education, recreation, means and speed of locomotion and methods of intercourse have all undergone vast changes, and those changes, some slow, some rapid, but all insistent, have had an effect on the character and life of the nation, greater probably than that of the changes of any previous period of the same duration.

Methods of manufacture have undergone radical changes, machine tools and shop appliances are now capable of dealing with many varieties of work with a degree of accuracy that has only been equalled by the best of skilled handicraft, and of turning out that work more rapidly and cheaply. The consequence has been that the proportionate number of these highly skilled workmen of whom we were always, and are still, so proud, tends to be a diminishing quantity. Fortunately, however, that smaller proportionate number aggregates, with the greater volume of work, to a very large number and probably an increasing number in the various branches of engineering. When James Watt was building his first engines he complained that he could not get sufficiently skilled workmen to give him an internal cylindrical surface true enough for a gasket-packed piston to work in. The changes in men and methods since that time have indeed been remarkable, and the most rapid changes have been made in the later half of the interval. In that period a great deal has been done to improve the hygienic conditions in the workshop, and for the safety of the operatives; also for the welfare and recreation of the workpeople. A contrast of a modern workshop, clean, roomy, well warmed and ventilated, and well organised throughout its details, with the shops of forty or fifty years ago, a contrast that many of us here present are able to make, is striking evidence of the remarkable progress that has been made in our methods and arrangements during that period.

But even more remarkable is the change that has been effected in the education, or rather I would say in the technical training, of the *personnel*. It is only in comparatively recent years that it has been thought necessary or even desirable to give any training to apprentices and boys other than their workshop training, and even that in many cases was arranged without much thought for the boy; it was often subordinated to more commercial requirements.

The changes that have been made so far in the endeavour to combine, measure for measure, handicraft or machine work with a knowledge of engineering principles have already been attended with beneficial results, alike to the apprentice and the master, and they have provided opportunities for lads gifted above their fellows, to rise to positions of authority and trust which otherwise would have been closed to them.

I am not sure, however, that the best has yet been attained in this direction or that the best means have yet been adopted, and I feel that some of the best work of the future lies in further improvements in our methods of training, and in suiting the quality and degree of the training to the capacity and the intended future of the individual. Youths should always be encouraged to connect the methods employed with the purpose at the beginning and the result at the end, and I am inclined to think that such encouragement not only rapidly develops the boys themselves, but proves ultimately to be of considerable all-round benefit.

Forty Years' Progress Reviewed.

In a maritime country like ours, whose very existence depends upon sea communication, it is only natural to expect that ships and the means of propulsion should have participated in the general progress that has been made, and that is quite true. Probably greater progress has been made in marine engineering during the last forty years than in any other application of technical science, except perhaps electrical engineering (a new industry in that period, and one therefore in which rapid progress could be anticipated), and even in that fascinating and highly progressive branch, marine engineering has had an important influence in the prior or concurrent development of prime movers of high power and speed. The progress in marine engineering throughout has been such as to make me feel that I have been fortunate in that my life has been placed in that period.

Changes of a far-reaching character have taken place in the propelling machinery both of the Navy and the Mercantile Marine, changes which in each service have been mainly of distinct character, but productive of experiences which have jointly been of considerable mutual advantage. In later years the striking changes have perhaps been evinced in the machinery of the Navy more than in that of the Merchant Service on account of the very high powers and speeds that have been required, but it is not always that the Navy has led in this respect. In my early days in the Navy perhaps the slowest steamships on the face of the waters were men of war, and I have taken part in some unauthorised but nevertheless real

* Abstract of Presidential Address delivered by Engineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D., before the Institute of Marine Engineers, September 12.

attempts to race merchantmen, and those not of aristocratic class, in which we were hopelessly beaten. Nevertheless, during the long and later period in which this order has been reversed, the Merchant Service has taken a valuable part in developments, the advice and help of its engineering experts have been freely sought and wholeheartedly given whenever required by the Navy, and in such matters the two services have been closely allied for many years. It is probable that, on account of the considerable diminution in Naval Shipbuilding, the Merchant Service will in future take a more prominent part in general developments than in the immediate past, although it may not do so in those features which are essentially Naval in their character.

In the Merchant Service, important increases in power have also been effected, but not to the same extent as in the Navy, and the general features of the great advance that has been made are the concurrent development of such of the means just indicated as are suitable, a larger utilisation of the expansive properties of steam, and a wider and more advanced use of superheated steam, the object being to obtain economical performance of a high degree.

In both services reliability has been the primary consideration, but while in the Navy the main efforts were directed towards protection of machinery, reduction of weight and endurance, providing for durability and making the best economic performance that those predominating conditions would allow, in the Merchant Service the most important aims were economy of fuel and a larger measure of durability. In both services the reciprocating steam engine has reached a very high standard of excellence in design and workmanship, its reliability and durability stand very high, it is easily manipulated, and in the Merchant Service, especially in those cases where high steam pressure, a high degree of superheat, and a high ratio of expansion are employed, its performance in point of fuel consumption has reached a very satisfactory stage.

Turbines and Reduction Gears.

These qualities are now associated with the steam reciprocating engine to such a degree that I am sure it will find favour in the Merchant Service for a long time to come.

This engine, however, is not suitable in marine work for the development of the very high powers required in warships and certain other vessels, and Sir Charles Parsons' application of the steam turbine to marine propulsion has enabled higher powers to be developed, and higher speeds to be obtained than would be possible with reciprocating engines.

His further conception and successful evolution of mechanical reduction gearing has also enabled a higher degree of economy to be realised than was possible with the reciprocating steam engine, and this has had its obvious effect in the application of the geared turbine to the cargo steamer of low power. Some practical troubles have been experienced in certain of these ships, but, judging from the more fortunate experiences in the Navy, I think that these troubles will be of a transient nature, and it can be expected that machinery of this type will be widely used.

In recent years the heavy oil engine has received considerable attention for marine purposes, the attraction being, of course, the cheaper cost of running that is anticipated, and it received an impetus during the recent labour troubles resulting in a shortage of coal supplies.

Progress with the heavy oil engine in Great Britain was for many years extremely slow, due presumably to the fact that, unlike other countries in which development had been more rapid, we had cheap and abundant supplies of coal, and also had had an immense and satisfactory experience with, and had reached a high stage of perfection in the reciprocating steam engine, in fact our commerce had been built up with this engine. The successful introduction of the turbine gave, in certain quarters, a set-back to reciprocating engines of all types, and this feeling also took a share in the relative retardation of the Diesel engine in Great Britain. For submarine work the oil engine was, and largely is, a necessity, and it was in these vessels that the marine oil engine was first used in this country, the earlier ones being petrol engines and all recent ones of the Diesel type. The Admiralty gave a further lead by fitting some of their auxiliary vessels of lower power with slower running oil engines of more commercial type, and I am inclined to think that the ordering of some of these engines from the Continent put British engineers on their mettle in characteristic and commendable manner and was the prominent factor in the real start of the industry in this country.

Last, but not least, in the period under review great improvements have been made in the status and conditions of service of the *personnel*, both in the Navy and the Mercantile Marine. This is only fair and just, having regard to the onerous and responsible duties of the marine engineer, and to the attainments necessary to enable him to perform those duties in the manner expected of him. In many cases the improvements have been tardy or are still in arrears, but the claims that have generally been made are not unreasonable, and should not long be delayed.

If the industry itself is depressed, I find no such depression among engineers in their regard for their profession. They are as enthusiastic as ever, and I think there is nothing to equal the enthusiasm of engineers for engineering. It is this liking and affection, combined with certain natural advantages, that has placed British engineering in the forefront hitherto, and if the same spirit imbues our younger brethren it will keep us there for many years yet. The country possesses these young engineers in large numbers, they are well trained, eager and full of enthusiasm. Taking a long view, the future of British engineering lies with these young men, and with the knowledge that I have of their ability and energy, I have no fear for the future, provided facilities are provided by institutes such as this and in other ways to enable them to follow their inclination. If this confidence is widely shared it should be very comforting, as the problems of the future will apparently be at least as difficult and exacting as those of the past and probably more so.

Future Problems.

It will be interesting briefly to consider the nature of some of the problems that will have to be faced in the near future by the marine engineer, and the qualities required of him in dealing with them.

The reciprocating steam engine has reached such a stage of perfection that no radical improvement in its performance is expected, and those to whom it is an acceptable type will take it in its present satisfactory form with the greatest confidence.

The steam turbine as a propelling engine is rapidly growing in favour and presents some interesting problems in the practical improvement of its details and in the endeavours to obtain a high thermal efficiency.

In the Merchant Service long running at steady speed, combined with a low fuel consumption at that speed is essential, and design and experience are concentrated on the fulfilment of those requirements.

In the Navy a large power for occasional use is arranged for, but the bulk of the steaming is executed at a very much lower power. Economy at low power has therefore a dominant effect in reducing the fuel bill of the ship. But economy at full power is also important, as the lower the steam consumption at full power the smaller the boiler installation, and this has to be seriously considered in relation to the limited space and weight necessitated in the general design of the ship. The two conditions are antagonistic, the turbine designed for economical working at full power cannot easily be arranged, still having regard to the limitations of weight and space, for economical working also at low powers and the customary way of settling the conflicting claims is to effect a compromise. Something is sacrificed each way, in economy and in weight.

To arrive at the proper decision, not only is a knowledge of the thermodynamics of the turbine required, but the conditions of working at sea must be brought to bear upon the question, and the best combination of the two will give the most satisfactory result.

Reduction Gearing Failures.

In order to combine a high turbine efficiency with a high propeller efficiency reduction gearing has recently been introduced. In this country the gearing has almost entirely been of the mechanical type and in several cases it has brought with it its own troubles, troubles involving problems of a highly interesting character. They take the form of breaking and occasional wearing of the teeth. Experiences have varied. In the Navy mechanical gearing has behaved satisfactorily, the failures have occurred chiefly in the merchant service. A comparison has naturally been instituted into the differences between the conditions of service, methods of manufacture and inspection, and other attendant circumstances in the two services. Time is too short to examine these differences tonight, they have already been, and will be more fully discussed on more suitable occasions, but the point I wish to bring out is that the discussions that have taken place show that the marine engineer, in order to take the important part that belongs to him, must have a clear notion, perhaps much clearer than it now is generally, of the nature of the transmission of power by helical toothed gearing, of the action between the teeth, and of the movements of the teeth in contact relatively to one another. In these discussions another situation has arisen, not however for the first time. It has been supposed by some that in the cases of failure the material has been at fault, and the general impression I have formed is that the suspecting engineer, however warranted his suspicions may have been, has not been able to carry the charge far enough. I have urged for a long time that the practising engineer of the future must possess a better knowledge of physical metallurgy than he generally possesses at present, and by this I mean a general knowledge not only of the mechanical properties of the metals he uses, but also of their structure, and the changes to which they are liable in use, or which can be produced in them by working and by heat treatment. This subject, in its elementary form, must form part of the training of our young engineers, and this matter so much concerns marine engineers that I consider this address a suitable place to repeat the advice.

In America, very high boiler efficiencies have been claimed, under certain conditions and with special fittings, which, if maintained on service afloat, will put our engineers on their mettle, and in order to ensure that we shall maintain pride of place, it will be necessary for the marine engineer, to whom this problem principally belongs, to have a very wide knowledge, not only of the methods of efficiently burning oil fuels, but of the nature of the fuels themselves, and of the conditions affecting their efficient and economical combustion.

Need for Diesel Research.

Oil engines for propelling and auxiliary purposes will compel profound consideration for many a long day, and in the near future discussions may take in large part a different form. Before development can proceed much farther we shall have to get farther back into the cause of things, and endeavour to ascertain the nature of the physical and chemical changes which occur during the several stages of the cycle, the conditions affecting penetration and dispersion of the fuel during the period of combustion, the causes and effects of detonation, the nature of the combustion of the oil itself, and the changes of temperature in the gases throughout the cycle. Much more than is known at present must be elucidated respecting temperature changes in the materials exposed to heat, and the manner in which those materials behave and change while undergoing rapid fluctuations of temperature.

All this, and much more, must at the proper stage be regarded from the engineering standpoint, and that is in the effect of these occurrences and changes upon the suitability and reliability of the machinery for prolonged service at sea. In this exploration, there is probably much preliminary work for the physicist and chemist, and collaboration with other institutions and bodies who are recognised as being more expert in some of the factors will be most helpful, but the experience of the marine engineer, either as manufacturer or as user, will always be most valuable and in many respects indispensable, and it will be incumbent upon him to equip himself in due measure with scientific knowledge to enable him to give his opinions and advice with effect.

The Institute's programme for the coming season* indicates the great interest that the members take in the problems of the heavy oil engine, and judged from the titles of the papers, the work of the session in this respect should be instructive and valuable.

Importance of Training.

The most important factor in my opinion is to ensure that the best education and training that is practicable and which will be the most useful to them in the parts they are going to take in life, is given to our young engineers. This Institute takes great interest in its students and graduate members and is doing its share in the encouragement of these young men. If any improvement is needed in this direction, it may be in fostering a better connection between education at school and training in the workshop or afloat. In a Presidential Address recently given to the Southampton University College Engineering Society, I urged the importance of this connection, and made some outline suggestions for attaining it. In engineering, especially at the present day, both the theoretical and the practical sides have their special values, but they cannot be separated. There must always be experts on either side, but there must also be common ground on which all can meet, and on which views can be on all sides expressed, and heard with respect. Institutions such as this provide in this respect for their members, and for the encouragement of their students, possibly their influence might be extended further back for the better preparation of younger aspirants.

In all branches of engineering and in many other professions it is a matter of regret that experiences are not brought as fully as they should be into the common fund of knowledge or into the field of discussion. That is, I think, true in marine engineering. There is a saying in the Apocrypha that "the wisdom of the scribe cometh by opportunity of leisure," and I have often heard that sea-going engineers have no time for writing papers. I rarely accept that as the real reason, the fact in many cases is that they are either too reluctant or feel that what they have to say can be said, and said to the point, in much fewer words than those that go to make up the ordinary paper. The sea-going engineer is a very observant man, he must perforce be so; he is always engaged in diagnosis in which his judgment must be sound or failures will result, and he often has not only to judge but to act promptly to avoid accident or disaster; his judgment is tested by his action. The experiences of these men ought to be available to a much greater extent than they are at present for the general good. Some institutions provide for cases of short papers or descriptions by styling them "Notes," which may or may not be subject to discussion, and a similar method has been adopted by the Admiralty in the circulation of similar information among engineer officers of the Navy. The Institute of Marine Engineers gets very good value from those who will write or talk, or do both, cannot it also arrange to squeeze the more modest and more numerous portion of its members, for the greater good of all.

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*See *The Marine Engineer and Naval Architect*, September issue, page 335.

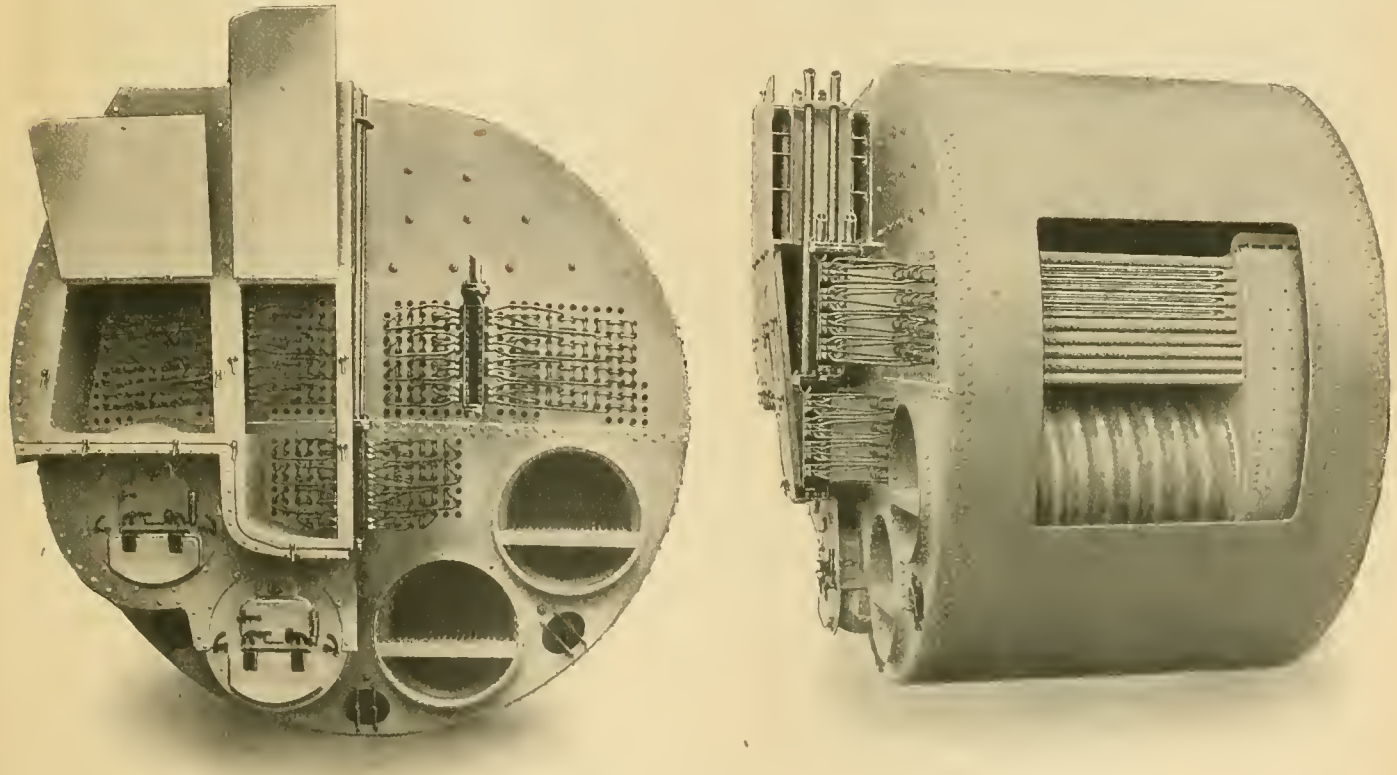
SUPERHEATERS AS APPLIED TO MARINE BOILERS.

Early Failings of Superheaters—New Wrought Steel Robinson Header—Method of Manufacture adopted for Element Ends.

It is not so very many years since superheaters enjoyed only a lukewarm reception from marine engineers generally, and in justice to these engineers it must be admitted that the unreliability of the superheaters fitted some years ago, resulting in their disuse after a brief period of service, gave sufficient cause for lack of confidence. Happily, to-day, improved materials and methods of manufacture have combined to invest the marine superheater with a degree of reliability favourably comparable with practically any other marine auxiliary, and, moreover, the economies to be obtained by its use are such as to merit the attention of the shipowner who is primarily concerned with the reduction of operating costs. Unlike the stationary engine or the locomotive, the marine engine derives its energy from fuel, the provision of which entails a supply sufficient for weeks and sometimes months of working. The constant carriage of this fuel supply renders the question of fuel economy at sea of the highest importance inasmuch as each superfluous ton of fuel carried virtually represents the equivalent of one ton deadweight cargo loss.

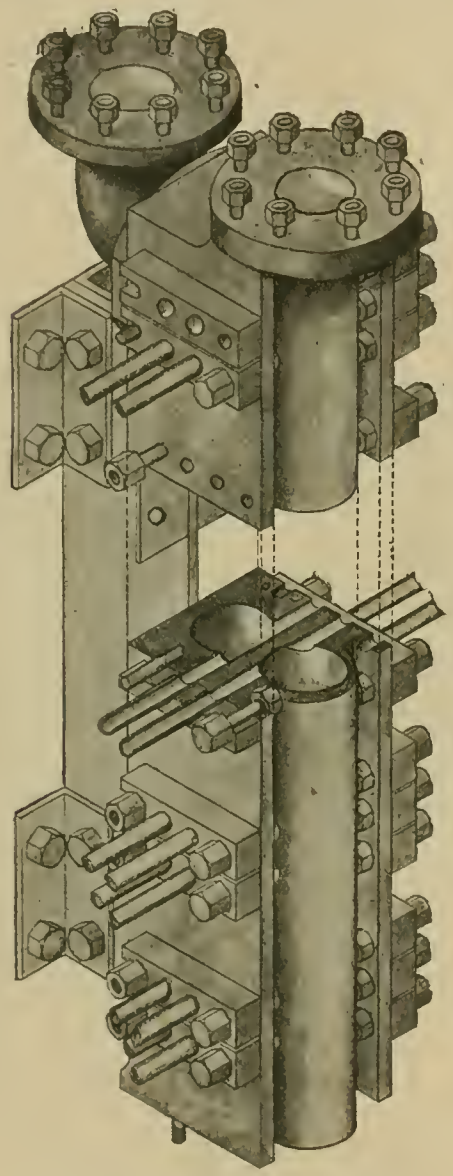
Shipowners are not as a rule unduly conservative, and are ready to adopt any method of fuel saving which they are satisfied will show an increased trading revenue and at the same time prove reliable under the exacting conditions of marine service. When the increased economy provided by the great range of expansion and absence of steam losses in the modern steam turbine working with a very high condenser vacuum became evident, shipowners were not backward in adopting this method of propulsion. The increased economy obtainable by the use of highly superheated steam is very considerable, being approximately the same as that gained by the use of triple or quadruple expansion instead of compound cylinders, while on the other hand the addition of the necessary superheating appliances to the boilers is a comparatively simple matter involving but few modifications in the existing plant. Apart from the smaller consumption of steam in lbs. per i.h.p., an additional gain is effected by reducing the heat of the waste gases and the net result is the utilisation of a greater proportion of the total heat in the fuel.

There are many types of superheater on the market to-day, but in this article we propose to confine our remarks to a description of the more important features of the Robinson superheater as manufactured by the Superheater Corporation Limited, of 14, New Burlington Street, London, W.1. This superheater is of the smoketube type and consists of a number of solid drawn mild steel tubes of special form which are placed inside the ordinary tubes in a Scotch return tube boiler. We publish on this page front and side views showing the method of attaching this superheater to a standard marine boiler. The superheating pipes are so connected with the steam supply from the main stop valve that the steam on its way to the engine is caused to traverse the whole of the superheating pipes, which conduct it from the smoke-box to the combustion chamber end of the tubes and back. The pipes are connected up in groups, or elements, each of which consists of two, three or more "U" shaped ends in series, each bend being a separate tube. The return bends at the combustion chamber end where the tubes



Front and Side Views showing Method of attaching Robinson Superheater to Standard Scotch Marine Boiler.

turn sharply through an angle of 180 deg., and where most of the heat transference from the hot gases to the steam occurs, are of special design and construction. The steam from the main stop valve on the boiler is delivered to one or more headers according to the number of furnaces in the boiler. These headers are placed vertically between the sets of tubes belonging to each furnace and are secured to the tubeplate. They are each divided into two chambers, one for the reception of saturated and the other for the collection and distribution of superheated steam. One steam chamber is connected to the

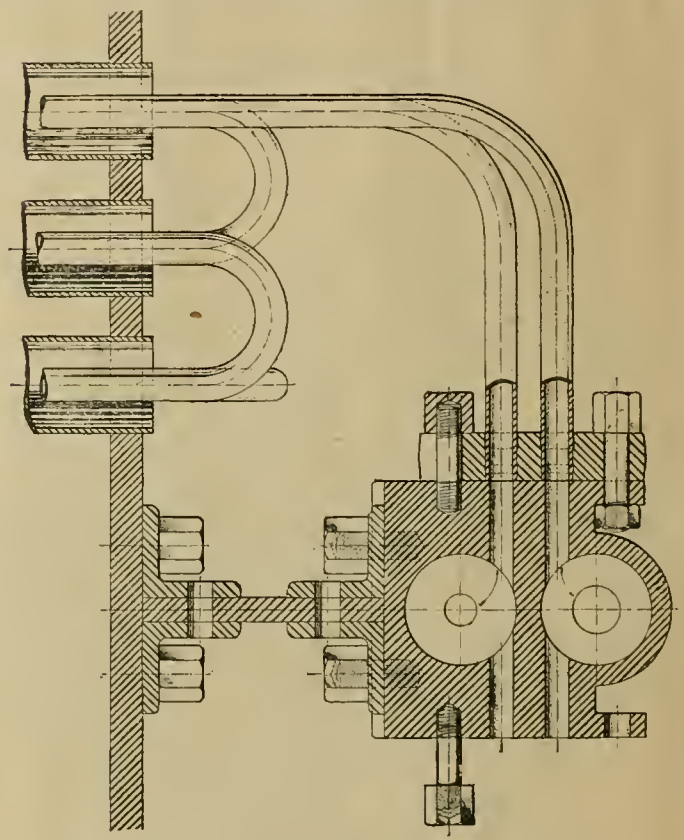


New Wrought Steel Type Header.

main steam from the boiler, and the other to the main steam pipe to the engine. The sets of " U " pipes or elements, as they are called, are so connected up to the headers that each has one end in communication with the saturated and the other with superheated steam chamber of the header.

The Robinson marine superheater is made in several forms, differing mainly in respect to the method of securing the elements to the headers. In the M.A. Type superheater, the end of the element is expanded directly into the sides of the header without the interposition of any flanges, bolts or studs. The header itself is made with an open front, which is closed by steel covers secured by studs and nuts, so as to enable the expanding and extracting tools to be introduced into the steam chambers. These tools are of a very simple character and the process of making a perfectly tight and reliable expanded joint, as well as that of extracting an element, is one that can be performed effectively and rapidly with but little skill. Extraction of an element is carried out without injury to the metal of the pipe and hole, so that an element can be expanded and removed several times. A feature of this header has reference to the small number of joints necessary, in fact, the superheater is for all practical purposes solid metal throughout.

There are, however, some engineers who prefer to have the elements secured by bolts or studs to the header, so that they can be fixed or withdrawn with no other tool than a spanner, and to meet this preference the M.B. type of marine superheater header has been designed. In this type the two ends of each element are expanded into a common flange block which is faced



Method of attaching Elements to New Header.

and secured to the header by two studs. Cross channels or gates are cut in the block in way of the studs so as to enable the flange to pass over their ends when inserting or removing the element. In order to prevent any possible axial movement of the pipes in the flange block, grooves are cut in the latter, into which the circumference of the pipes is pressed by the expanding tool. With this arrangement there is no difficulty in making and maintaining a steamtight joint between the block and header. There is one stud per pipe instead of two pipes per stud as in most other arrangements, and the flat faced metal-to-metal joint is one to which every engineer is accustomed, and one that has proved its efficiency in practice.

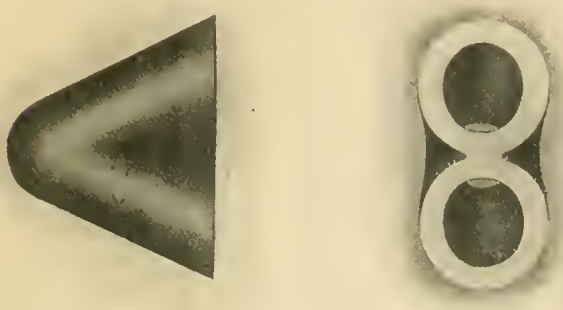
A progressive step has been made with the introduction of the M.C. type of marine superheater header with which design, in the majority of installations, any of the superheater elements can be readily removed and replaced without interfering with any other element. In this type the header is of plain rectangular section with a longitudinal division wall forming the saturated and superheated chambers. The superheating pipe flange block connections lie transversely with the header and are arranged horizontally so that the steam from the saturated chamber may pass through the elements and return to the

superheated chamber, from which it passes direct to the main steam range. At the base of the header, for inspection and cleaning purposes, a cover plate is fitted to which are attached the drain valves. Any sediment collecting in the header can be dispersed by periodically blowing through these valves.

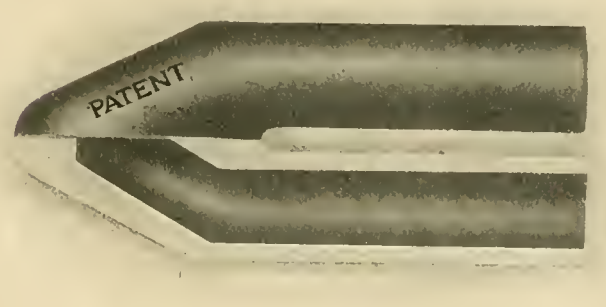
The elements are expanded into the flange blocks as in the M.B. type and are secured to the header by means of studs and bolts. The joint is of the flat faced metal-to-metal type, which is of known and proved efficiency, and is familiar to all engineers. To remove any element the rear stud-nut is slackened and the front bolt withdrawn, when the element is free and can be readily removed without having to spring it from, or guide it over, studs. The latest development in the design of Robinson superheaters is the introduction of a patent wrought steel, two-compartment header which embraces the features of the M.C. type and further embodies the advantages of being manufactured from wrought steel, thus eliminating the difficulties and defects at times experienced with steel castings which have to be machined. This type of header, known as the M.D. type, is illustrated on page 404. Essentially, the header consists of a steel ingot which has two parallel holes drilled to form the saturated and superheated chambers. The sides of the headers are accurately ground to receive the faced element flange blocks which are secured by means of studs in the rear and bolts in the front, as illustrated. Holes are drilled in the sides of the header communicating with the saturated and superheated chambers enabling the saturated steam which enters the rear compartment from the boiler-stop valve, to pass through the elements in the usual way into the front or superheated chamber and thence by steam pipe connection from top of header to turbine or engine-stop valve. The header is secured to the boiler front by angle iron and stiffening plate. Drain cocks are fitted to the bottom cover plate which, if blown through periodically, ensure the removal of any sediment that may collect due to boiler priming, &c. The bottom cover plate is easily removable, and the internal parts of the header are thus readily accessible for inspection and cleaning purposes.

A special feature of the Robinson superheater has reference to the weldless solid forged-steel element ends. The method of manufacturing these ends is by drop-forging to the shape shown in the illustrations above. Thereafter the ends are machined internally from the solid to provide the return passage as shown. By this method, complete solidity is provided and a predetermined thickness of homogeneous metal is assured. These mild-steel ends are butt-welded to the superheater pipes, and experience has shown that ends of this type have a very high capacity to resist the destructive action of high temperature gases and have, in many cases, outlived the tubing from which the superheater elements are made.

The Robinson superheater has been fitted to vessels representative of the principal steamship lines in this country and also in France and Italy.



Solid Forged-Steel Element Ends before and after Drilling.



Element End connected to Main Body of Element.

THE "SPROULE" INTERNAL-COMBUSTION ENGINE.

A new type of internal-combustion engine, the "Sproule," has recently been devised. The internal-combustion engine in general is extremely efficient, but it has the drawbacks of limited flexibility and absence of overload capacity, low efficiency at light loads, and difficulty of reversing. It is claimed that the "Sproule" engine will overcome these drawbacks.

The cause of the reduced efficiency at light loads is to be found in the system of control, which means low compression at such loads; and, roughly, the efficiency increases proportionally to the compression. In the "Sproule" engine the control to suit varying loads is obtained by varying the amount of the charge, but always retaining full compression as far back as half-load.

The design of the engine consists of a pair of pistons working to a common combustion space, each operating a separate crankshaft, the two shafts being geared together as 2 : 1, so that one piston makes two complete strokes, while the other makes four, per cycle. The method of gearing the two cranks is such that the relative setting of the two crankshafts angularly to one another can be varied at will, whether the engine is in motion or not. When the two cranks are set so that at a given time in the cycle the two pistons are together at the back end of their strokes, the minimum compression space is available. In this case a small charge of gas will be compressed normally, but will be expanded to more than its original volume, giving an extra efficiency. If now the two-stroke crank be advanced relatively to the four-stroke crank, the two pistons cannot coincide at the back position, so that the minimum compression space becomes the fixed space, plus a small portion of the two-stroke cylinder volume, the total giving the larger space necessary for a heavier load. The expansion ratio will now be less, but up to the normal full load it is still greater than the compression ratio, and gives a high expansion efficiency at loads up to full load. The two-stroke crank may be advanced to give about 40 per cent. more than normal full load charge, the expansion ratio being then a little lower than the compression ratio, so that a large overload capacity is provided with only a slight drop in efficiency. It is claimed that this engine, while, of course, retaining all the advantages of the internal-combustion engine, is as flexible as the steam engine, and, should this be the case, its interest to marine engineering will be obvious.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

The Strength, &c., of Concrete Ships in Service.

The classification societies require that the longitudinal strength of a concrete vessel should be at least equal to that of an otherwise equivalent steel vessel. With increasing age of a vessel the concrete will actually increase in strength, while a steel vessel must inevitably decrease in strength due to corrosion. In this respect a concrete vessel is, therefore, actually stronger than a supposedly equivalent steel ship. However, with regard to local strength it is practically impossible to make the concrete of equal strength to the steel, and especially is this so for the strength of the shell between the frames. Concrete ships have received most of their damage due to, what would be for a steel ship, unimportant collisions. This is somewhat remedied by fitting wood-rubbing pieces, and by the fact that any damage actually incurred can be immediately repaired *in situ* by unskilled labour. The cost of upkeep of a concrete ship, in spite of this sensitivity towards local damage, is considerably less than that of the steel, because no painting, &c., is required. With regard to economy of running, the concrete ship is superior to the steel because of its smoother hull. In fact, in spite of the heavier hull weight, the concrete ship can carry more deadweight at a given speed for a given expenditure of power than can the steel vessel. This fact ought to receive considerable attention in the future, for it is being proposed in Germany to base the towing rates on the resistance of the vessel to be towed. This should prove a considerable attraction towards the construction of concrete barges. Whilst experience in the construction of concrete vessels is still young, the suitability of concrete for such vessels as barges, pontoons, floating docks has been definitely proven, and as greater experience is gained the range of application will possibly be considerably increased.—*Dr. Teubert*, "*Der Kleinschiffbau*," August 12, 1922, p. 205 ; 1 p.

The Flettner Rudder.

In this article the fundamental considerations governing the design of the Flettner rudder are described. The idea of the auxiliary flap was first conceived by the inventor for use on German aeroplanes. After the war the idea was applied to ships, and the Dutch vessel *Frigido* has now been successfully fitted with the Flettner rudder for almost two years. The principle of the rudder is so to rotate the flap at its after edge that the pressure and suction faces of the flap are opposite to those of the main rudder. For any given rotation of the flap the main rudder will automatically rotate until its moment about the rudder head is equal to that of the flap. Hence, as only a hand wheel is necessary to turn the flap rudder and thus the whole rudder, the usual steering engine can be entirely dispensed with. For auxiliary purposes a quadrant is attached to the main rudder head and power is obtained from a warping winch. Full constructional details are given of the *Frigido's* rudder and also of that of the 8,000-ton twin-screw motorship *Odenwald* at present under construction at the Deutsche Werft, Hamburg for the Hamburg-Amerika Line. In addition, a description is given of the experimental apparatus used at the Hamburg Experiment Tank to determine the respective moments of the flap and main rudders. A photograph showing the flow round the model rudder and a sketch showing the construction of the research apparatus is also included in the article.—*Anton Flettner, Werft, Reederei, Hafen*, August 22, 1922, p. 537 ; 8½ pp ; 26 *ff.*

Education of Moulder Apprentices at the M.A.N. Company's Works at Nürnberg.

The Maschinen-Fabrik Augsburg Nürnberg have, as far back as 1889, taken a definite interest in the education of their apprentices. All apprentices entering their employ receive a three or four years' technological and general education. One of the principal departments of their work school is that devoted to the training of moulders, one of the most difficult of all manual trades. The success of their training methods has been reflected in a request from the recently-appointed German Committee on Technical Education to allow their system to be published as a guide for all other works. The present series of articles is not complete, but it contains much valuable information on suitable curricula and methods which have definitely proved successful in the past. In the course special practical instruction in an apprentices' foundry is combined with blackboard instruction, and, in addition to the moulding and foundry technique, sufficient is taught of such allied trades as patternmaking as to ensure subsequent intelligent co-operation between the two trades. Apart from the trade aspect of the training, a considerable amount of time is devoted to instruction in citizenship, works hygiene, &c., and also to all branches of sport. The present articles are exceptionally well illustrated and should prove of interest to those who realise the intrinsic worth of a thoroughly trained workman.—*T. Seyfried, Werkstattstechnik*. July 15, August 1, 15, p. 405, p. 471 ; 20 pp. ; 42 *ff.*

The M.A.N. New 1,600 b.h.p. Four-stroke Diesel.

Previous to the war the Maschinen-Fabrik Augsburg Nürnberg Company were building slow-running Diesel engines. During the war their experience in this direction was interrupted, and their attention was turned to the development of the high-speed submarine Diesel. Now the company has returned to the construction of the slow-running four-stroke type, and have just completed a 1,600 b.h.p. set for a twin-screw vessel of 9,300 tons d.w. being built by the A.G. Weser at Bremen. The engine develops its specified power at 100 r.p.m. and has six cylinders of 700 mm. diam., with a piston stroke of 1,700 mm., the mean effective pressure being 5·2 atmospheres. The engine has several interesting features, notable amongst which is the construction of the cylinder cover, which is so designed as to increase the velocity of the cooling water round the fuel valve, thus obtaining greater uniformity of temperature and hence stress. The engine is designed to run on tar oil and crude oil, these oils being fired by the preliminary introduction and explosion of a lighter oil such as shale or gas oil. Exhaustive trials were carried out on the engine and a 700 hours' non-stop test was made. The results of the test were highly satisfactory, the fuel consumption on tar oil being ·438 lb. per b.h.p.-hour with ·023 lb. per b.h.p.-hour light oil for firing. The corresponding consumption for crude oil was ·35 lb. and ·023 lb. per b.h.p.-hour respectively. The heat consumption per b.h.p.-hour in calories was 1,888 and 1,871 for the tar oil and crude oil respectively. The test results are given in a complete manner, full chemical particulars of the fuels used being published. Among other interesting data is an examination of the vibration of the shaft by means of a Geiger torsiograph. By this instrument the stresses in the shaft can be simply determined. The article contains much information on this new product of the M.A.N. Company. —*Schiffbau*, August 9, 16, 23, pp. 1, 231, 255, 9 pp; 15 *ff.*

Compressed Air for Ship Salvage Work.

The practice of pressing out the water from the damaged compartments of ships by means of compressed air has increased considerably of late years. Apart from developments in pneumatic machinery, one explanation of this increased practice is the fact that modern ships have been constructed not only watertight, but airtight. With the older vessels it was impossible to utilise compressed air because of their leaky construction. Before any pneumatic salvage work is undertaken the sunken structure should always be examined from a strength standpoint, for, when the water has been pressed out at a considerable depth, as the ship rises the internal air pressure may be sufficient to burst the shell and deck structure. Accidents of this description were not infrequent at the beginning of pneumatic salvage. Different methods are naturally adopted for the salvaging of sunken and stranded ships, the former requiring pneumatic plant much more powerful than the latter. The maximum depths at which salvage is usually attempted are from 30 to 40 m., and at these depths an air pressure of seven atmospheres is required to work any submerged pneumatic machinery, whilst only three atmospheres pressure is required to press out the water. Many interesting problems occur in this class of work, calling for the carrying out of considerable technical work on the vessel's submerged stability and trim. The use of pontoons and "camels" is increasing in this class of salvage.

With stranded vessels the difficulties are usually much less than with sunken vessels. Given decent weather all salvage plant can be fixed on the wreck itself and preliminary caulking of the deck can be simply carried out. In these cases, when the ship's main machinery is disabled, the compressors can be conveniently driven by a petrol motor, and thus work completely independently of the salvage vessel. Many other interesting points are raised in this article and the manifold applications of compressed air in salvage work are clearly demonstrated.—*E. Oppenheimer, Schiffbau*, August 16, 23, 1922, p. 1,266; 2½ pp.

Electric Welding for Shipbuilding.

In connecting the constituent parts of a ship's structure it is essential to make the connections as efficient as possible, for, without strength and watertightness, the ship cannot function. For many years riveted connections have been used exclusively in ship work, but the related technical and theoretical investigations cannot claim to have brought about any improvement above that forthcoming from the normal evolution of experience. Recently electric welding has come into the field, and because of its many advantages it should undoubtedly eventually prove a serious competitor to riveting. Electric welding results in a saving of labour, material, fuel and operations, because with its use caulking, punching, drilling and riveting are eliminated. When carefully carried out the welded joint is stronger than the riveted joint, for the line of weakness through the rivet holes in the latter is done away with. Many methods have been produced for electric welding since 1860, when Wilde, an Englishman, first conceived and applied the idea. In this article attention is chiefly directed to the Kjellberg process. Although possible applications are manifold, it will have to be definitely established that electric welding is equally reliable and considerably simpler and cheaper than existing methods, before it can be expected to be universally adopted. Data on the cost of welding are not very plentiful, but from experiments carried out at the Germania Werft it was found that electric welding was 31 per cent. cheaper than oxy-acetylene. Further, in the case of two barges recently constructed in America, one riveted and the other electrically welded, the cost of the latter was 16 per cent. less than that of the former. However, as the whole operation of electric welding can be accurately analysed from the point of view of current and material consumed, the estimation of the cost of an operation may be simply determined. The present difficulty is undoubtedly the dearth of skilled workers, but, once this difficulty is removed, electric welding will, beyond question, largely replace riveting in the future construction of ships.—*Dr. F. W. Achenbach, Schiffbau*, August 2, 1922, p. 1,207; 4 pp.; 2 *ff.*

Research Statistics.

This article forms a very interesting contribution to the vexed question of the presentation of experimental results. Following up a method first suggested by Eiffel, the author is able to portray in one diagram, logarithmic in principle, five or six curves which connect the eight or nine variables absolutely essential for the comparison and combination of open propeller, model and trial results. The method is especially convenient, as it enables the propeller, hull and propulsive efficiencies to be immediately visualised. Various examples are given of the application of the method, one of which is now the classic case of the American destroyer *Pruitt*. The formation of the diagram brings out very markedly the occurrence of cavitation in this example. Next, an ingenious presentation of Schaffran's systematic model propeller research, series A (three-bladed), is given, and is in an immediately convenient form for use with the previously referred to general analysis diagram. To convey the same amount of information by the ordinary Schaffran treatment requires forty diagrams as compared with the present author's two. In the second part of the article a general criticism of experimental work is given. One very important point is emphasised, this being the absolute necessity for research workers to publish their actual experimental results and not the usual delightfully smooth and apparently beyond reproach curves which are, it is regretted, almost invariably presented to the outside world. The peculiar construction of the author's general analysis diagram brings out a number of appreciable irregularities in the Schaffran standard series, which, owing to the cloaking of the experimental values, cannot satisfactorily be explained. Several other interesting anomalies and shortcomings of experiment tank work are referred to. The ideas and information in the article should prove of considerable assistance to designers.—*Dipl. Ing. Schmidt, Werft, Reederei, Hafen*, July 22, 1922, p. 425; 8½ pp.; 16 *ff.*

The Triple-Screw Intermediate Passenger Liner "Cap Polonio."

This article gives a very complete treatment of the design and construction of this well-known vessel of the Hamburg-South America Line. The *Cap Polonio* was the first serious departure from the unfortunate practice of carrying permanent ballast for stability corrective purposes found necessary in many German liners, for in it was utilised the old principle of girdling the vessel in the region of the waterplane. This girdling took the form of a bulge construction, which was so designed as to give the desired compromise between stability and easy rolling qualities at each particular draught of the vessel. Experiments showed that for a given displacement the bulge form had a less resistance than had the conventional form, and full particulars of these model experiments are given in the article. The design of the form, the stability, rolling experiments, the construction and accommodation of the vessel are very fully gone into. Complete weights of hull, outfit and machinery are given. The auxiliary machinery, such as winches, steering gear, wireless telgraphy, &c., is described in considerable detail. In the second part of the article the design and construction of the main machinery is described in the same complete manner as for the ship. The machinery consisted of quadruple-expansion engines on the wing shafts, and a low-pressure turbine on the centre shaft. Full descriptions of the main engines, boilers, auxiliary machinery, engine and boiler-room ventilation, &c. &c. are given. The following general particulars of the vessel may be of interest:—Length b.p., 634 ft.; normal breadth (moulded), 72 ft.; breadth over bulges, 79·6 ft.; depth to bulkhead deck, 34·5 ft.; gross registered tonnage, 20,576; net registered tonnage, 9,941; draught, 28 ft.; contract power, 18,000; contract speed on 24 ft. draught, 18·5 knots; service power, 16,000; service speed, 16 to 17 knots; deadweight, 8,400 tons; net steel, 11,000 tons; outfit, 5,200 tons; engine and boilers (gross), 3,000 tons; miscellaneous items, such as rust, waste matter, &c., 200 tons; light weight, 19,400 tons; load displacement, 27,800 tons. The article, which forms the greater portion of a special number of this journal, is presented in an excellent manner, and should prove of considerable assistance to designers of this class of vessel.—*Dr. Foerster and Obering. Sütterlin, Werft, Reederei, Hafen*, August 22, 1922, p. 488; 50 pp.; 109 *ff.*

The Graphic and Experimental Determination of Mass Moments of Inertia in Practice.

In the construction of large motorships it is necessary to investigate whether any considerable torsional vibration is likely to occur in the propeller shafting. To investigate this problem the elastic properties of the shaft and the moment of inertia of the revolving masses must be calculated. In practice three distinct cases may be distinguished. Masses which rotate concentric with the shaft, such as flywheels, gear wheels and turbine rotors; masses such as connecting rods, which have a combined reciprocating and rotational motion; and, lastly, such masses as pistons, piston rods and crossheads, which have a pure reciprocating motion. For the first class the moment of inertia may be graphically determined by construction of a diagram whose abcissae are radii and whose ordinates are the mass at any particular radius multiplied by this radius squared. The area under this curve over the total range of radius gives the required moment of inertia. To obtain the radius of gyration the total mass is required, and to obtain this a similar curve of radius mass is constructed, and by integration the total mass is simply obtained. The method can be extended to the case of ordinary connecting rods by a similar graphic integration. Perhaps the simplest way to determine the moments of inertia is by experiment, from which coefficients may be deduced for design work. Connecting rods can be considered as compound pendulums, and from their time of oscillation the moment of inertia can be directly obtained. Similarly, the moment of inertia of flywheels can be obtained by trifilar suspension or by attaching them to a thin vertical rod and obtaining the respective periods of vibration. For turbine rotors the simplest method is that of placing a weight of known mass and eccentricity on the rotor and balancing the rotor on circular supports, thus converting it into a cycloidal pendulum, from the period of which the moment of inertia may be found. A similar method can be used for the cases of the connecting rod. All necessary formulæ for use with this experimental work are deduced from first principles and presented in their most convenient practical form.—*C. von den Steinen, Werft, Reederei, Hafen*, August 7, 1922, p. 455; 4½ pp.; 14 *ff.*

NEW COMMONWEALTH GOVERNMENT LINER "JERVIS BAY."

The *Jervis Bay*, an illustration of which we show on page 380, is the third "Bay" steamer to be built by Vickers Limited, Barrow-in-Furness, for the Commonwealth Government Line of Steamers, of Melbourne and London.

The principal dimensions of the vessel are :—

Length, b.p.	530 ft.
Breadth, moulded	68 in.
Depth, moulded, to shelter deck	43 ft. 6 in.
Draught	29 ft. 11½ in.
Displacement	23,320.
Gross tonnage	13,837.
Service speed, loaded	15 knots.

Accommodation is arranged for 732 third-class passengers in two, four and six-berth cabins, in addition to accommodation for officers and crew to the number of 182. The *Jervis Bay* is of the shelter-deck with freeboard type and has, in all, six decks. A special feature of the vessel has reference to the large amount of insulated space, four of the holds and the 'tween deck space above being insulated. In general, the subdivision of the vessel complies with the full requirements laid down by the International Convention for the Safety of Life at Sea. Watertight doors, fitted below load line, can be operated both by hand and by the Stone hydraulic system from the bridge as well as at the door itself on either side of the bulkhead. The steering gear is of the Vickers electro-hydraulic type, consisting of two complete steering gears, each operated by a Williams Janney variable delivery pump. The gear is under complete control from the navigating bridge by means of a telemotor installation.

The refrigerating machinery consists of two horizontal compound marine type machines. Each machine has a compound steam engine, with cylinders 14 in. and 26 in. diam. respectively, by 21-in. stroke, and driving from the tail rod the horizontal double-acting CO_2 compressor. These machines, together with the necessary gas condensers, separators, circulating pumps, &c., are on "D" deck over the engine space. Four large "Sirocco" fans are fitted to circulate air through the insulated holds and 'tween decks when carrying fruit.

The propelling machinery, an illustration of which we show on page 379, consists of turbines of the Parsons type driving twin screws through double-reduction gearing. In arrangement, the main machinery consists of two sets of steam turbines, each set comprising one H.P. turbine of the reaction type, with one stage of impulse blades at the forward end, driving through a flexible coupling one pinion; and a reaction L.P. turbine driving, through a flexible coupling, the other pinion on the first-reduction gearing, and through this gearing to the gear wheel mounted on the main shaft. The complete turbine installation is capable of developing a collective shaft horse-power of 9,000 with the revolution of the propeller shafts about 90 per minute. The total power when working astern is about 63 per cent. of the ahead power. The casings of the high-pressure ahead turbine, and the steam-chest portion of the high-pressure astern turbines are made of cast-steel suitable for superheated steam. Adjusting blocks of the "Michell" type are fitted to the turbines. The main gear wheel is constructed with a cast-iron centre portion on which a heavy forged steel rim is shrunk, while the first and second-reduction pinions are of forged-nickel steel.

The steam-generating installation consists of three double-ended boilers and two single-ended boilers arranged in one compartment, and constructed to Board of Trade and Lloyd's requirements for a working pressure of 220 lb. per sq. in. These boilers are of the multitubular return tube type, fitted with smoke-tube superheaters, and Howden's forced draught.

THE REVIVAL OF CAST-IRON—I.—(*Continued from page* 378).

science. If the latter does them no harm, which is improbable, it is unlikely to do them any good.

The other side of the picture is more encouraging, and readers, if they exist as described in the following part of this essay, will doubtless recognise themselves.

Science Allied with Practice.

There are, here and there in England, and certainly also in Scotland, certain wonderful foundrymen. These men, born to be Dr. Steads, but forced by fate to be foundrymen, have observed and read and thought, every moment of their working lives. Not much can you tell them about silicon and manganese unless you know something about it yourself, not much can you swank to them about your metal, your cupola practice and your mixtures unless you know something about it yourself. These men are, many of them, practically unknown; they have lived unsung and unheard.

In a mighty manner, belonging only to the humbly intelligent, they are opening out the way for future generations of men blessed with better education and more chances than they themselves have had. The Institution of British Foundrymen is theirs; they might deny it, *would* deny it; but nevertheless, upon their strivings and upon their humility has sprung this institution. At first a mere weakly plant, almost a weed—now a flower of great promise. Whatsoever may result from the present movement towards progress in foundry-metallurgy is due to the efforts of these few men, efforts continued over years of work under astoundingly unprepossessing and discouraging conditions.

About the only reward they have had consists of the happiness arising naturally out of taking an unusual interest in one's job, thinking over it and studying it after working hours—thank goodness, nobody can deprive a man of that happiness.

Of such is composed the bed-rock of foundrywork in this island, and a fine rock it is. Were it not so we might well despair, for such men are not the majority.

In other spheres other men have done fine work for the cause of progress and science in cast-iron. Some employers have stood out pre-eminent, spending money upon laboratories in the face of sneers and disparagement of friends and foes alike. They have realised that the success, the lasting success, of their business is not to be entirely reckoned in terms of last year's dividend, and that a sound knowledge of their trade, of the science of their trade, is an asset to be reckoned not to-day but to-morrow. "Sufficient for the day is the evil thereof," is a saying with more than one translation and more than one moral.

The war put science upon its feet in this country. Firstly, it compelled the die-hards to ask its aid in order to save their skins. Next, it compelled people to realise that, by reason of her science Germany was able to challenge the best part of the world, either in commerce or on the battlefield. We know how much it cost us and all our allies to vanquish her, and we know which way the commercial war was going previous to 1914.

Hence science is in the position of being able to speak out, "straight from the shoulder," and no longer can the devotees of commercialism say they "do not believe in science," and deliberately starve scientists into silence. Science is top-dog in commerce to-day; from peaceful penetration and the value of the mark up to the making of cast-iron is science a sure winner.

Having stated that we have some wonderful foundrymen and employers delving away at the mysteries of cast-iron, it will be instructive to review what the world is doing, so far as the author knows it.

(*To be continued.*)

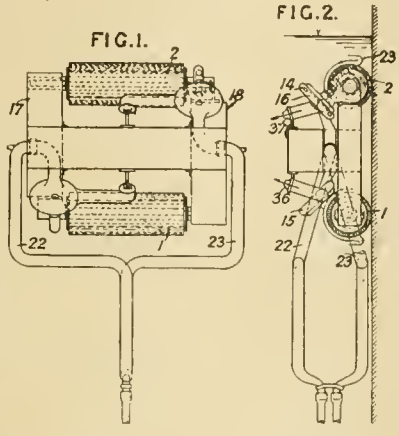
RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 182,096. Scrubbing Ships' Hulls.

Thorsen, L., 18, *Haakon Jarls Gate, Stavanger, Norway. May* 10, 1922, *No.* 13238. *Convention date, June* 23, 1921. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Class* 113 (*i*).]

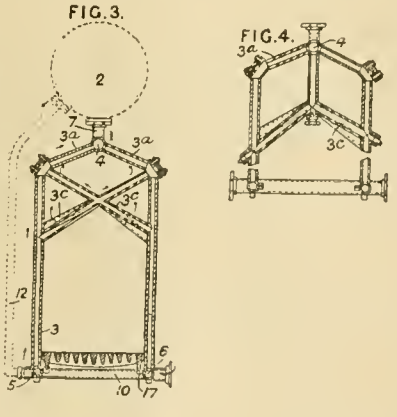
In scrubbing apparatus for ships' hulls comprising positively rotated brushes pressed against the hull by the reaction of a water jet, the oppositely-rotating brushes 1, 2 are operated by turbines 14 enclosed in casings 15, 16 mounted adjacent to buoyancy tanks 17, 18, the outflow from the turbines issuing from inclined nozzles 36, 37. The inlet pipes 22, 23 are associated with distributing-valve carried on a boat, and by regulating the relative supply of pressure fluid to the respective brushes, the apparatus can be caused to travel up and down the hull. The ballast tanks are dimensioned as regards thickness so as to compensate automatically for the variable weight of the supply conduit.



No. 182,143. Steam-generators.

Smith, D. V. H., 2, *Viewmount Drive, Maryhill, Glasgow. September* 30, 1921, *No.* 34662/20. [*Class* 123 (*ii*).]

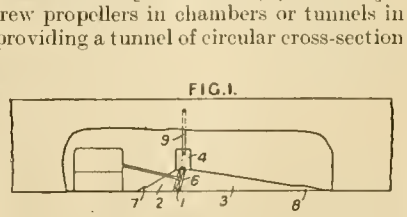
A water-tube boiler is built up of sections each consisting of an upper header 4, Fig. 3, two bottom headers 5, 6, vertical side tubes 3, and inclined top and cross tubes 3^a, 3^c, which form upper and lower longitudinal flues. The gases pass through spaces between the lower parts of the cross tubes into the lower longitudinal flues and enter the upper longitudinal flue through an enlarged flue space in a modified end section, Fig. 4. The upper flue opens into the chimney. The sections are connected to a steam and water drum 2 by upper connections 7 and by downcomers 12. Tubes 10 connecting the bottom headers are formed with projections 17 forming supports for the grate.



No. 182,221. Propelling Ships.

McReynolds, H., 82, *Crawford Street, Bryanston Square, London. March* 31, 1921. *Nos.* 9650 *and* 34939. [*Classes* 113 (*ii*) *and* 114.]

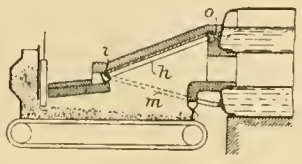
Relates to boats with screw propellers in chambers or tunnels in the bottom and consists in providing a tunnel of circular cross-section with an opening at the bottom, the tunnel being enlarged in the plane of the propeller and decreasing in section forward and aft. Above the propeller an air-escape tube is provided, the outlets from which have non-return valves which are closed automatically by the rising water when all the air is exhausted from the tunnel. The opening in the tunnel may be closed by a sliding plate when the propeller is not in use. The propeller 1 is located in a tunnel in the bottom of the boat, the tunnel being circular in cross-section with the bottom quarter formed with an opening. The tunnel is enlarged at 6 to accommodate the propeller, the forward part 2 has a slope of about 45 deg. and the after part 3 has a slope of 80 deg., the extreme forward and after ends 7, 8 being flared or enlarged. Above the propeller is a communicating chamber 4, from which pipes 9 pass outward above the water-level, the pipes having non-return valves.



No. 182,300. Steam-generators.

Hungenberg, P., Gummersbach, Rhineland, Germany. June 4, 1921, *No.* 15538. [*Classes* 51 (*i*) *and* 123 (*ii*).]

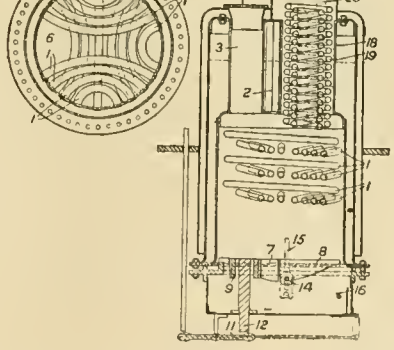
In an externally-fired boiler having inclined water-circulating tubes *h* arranged along the inside of the furnace crown, the tubes being connected to headers *o*, *l* within the walls of the furnace, the front header is connected at the side of the furnace to the lower part of the boiler by pipes *m*, which do not extend over the furnace. The rear header may be so connected to the boiler that steam may pass readily from the header into the boiler steam space.



No. 182,391. Steam-generator Furnaces.

Hazell, R. L. K., 23, *Lexden Street, Lexden, Essex, and Davey, Paxman & Co. Limited, Standard Iron Works, Colchester. November* 11, 1921, *No.* 30138. [*Classes* 51 (*i*), 123 (*ii*), *and* 123 (*iii*).]

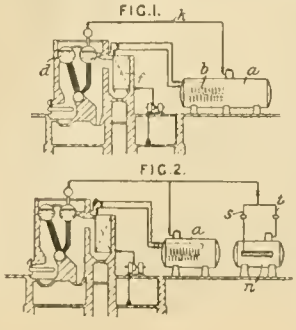
Grates.—In a vertical steam-generator having horizontal water-tubes 1 in the fire-box and vertical smoke-tubes 2, the water-tubes are arranged to leave a space 6, Fig. 3, through them immediately below a fuel-delivery shoot 3 which extends downwards through the water and steam space. The grate is formed in two parts, the part 7, beneath the space 6, being fixed and provided with a pison adapted to be reciprocated vertically, within a cylinder 9, by a rocking-lever 11 acting on the lower end of a spindle 12 connected with the piston. The other part 8 of the grate is pivoted at 14 so that it may be tilted by a handle 15 to dump the ashes into the ashbox 16. A superheating-coil 19 is arranged in a flue-tube 18 which, with the smoke-tubes 2, leads into the uptake 20.



No. 183,128. Steam-generators.

Marguerre, F., 19, *Prinz Wilhelmstrasse, Mannheim, Germany, and Hausmann, M.*, 30, *Xantenerstrasse, Berlin, July* 12, 1922, *No.* 19166. *Convention date, July* 12, 1921. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Classes* 64 (*i*), 64 (*ii*), *and* 123 (*ii*).]

In a steam-generator subjected to varying demands, excess heat is taken when the demand is low to a storage vessel by means of a steam pipe or a water-circulating pipe, and the stored heat is used when the demand is high to heat the feed-water. The heat-storage vessel *a*, Fig. 1, is charged by excess steam led from the generator

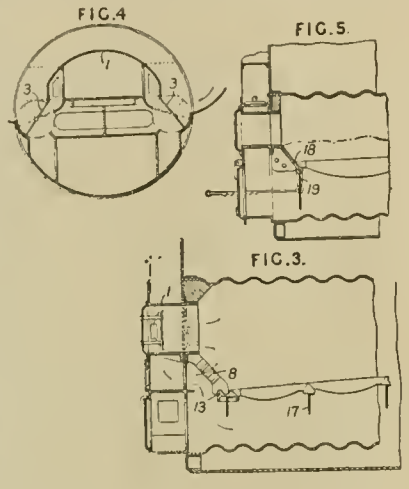


d by a pipe *k*. The vessel contains a pipe coil *b* through which the water from the economiser *f* may be passed before entering the generator. The steam pipe may also open into an ordinary heat-storage water container *n*, Fig. 2, the two branches *s*, *t* of the pipe being fitted with non-return valves or the like, the branch *s* serving to introduce the steam into the container and the pipe *t* serving to withdraw it. Other types of storage vessels, such as those containing salt solution, may be used in place of the water container *n*. The stored heat may be partly used for heating purposes instead of being returned to the generator.

No. 182,498. Furnaces.

Reid, J., 4, *Lloyds Avenue, London. January* 7, 1921, *Nos.* 878 *and* 2448. [*Class* 51 (*i*).]

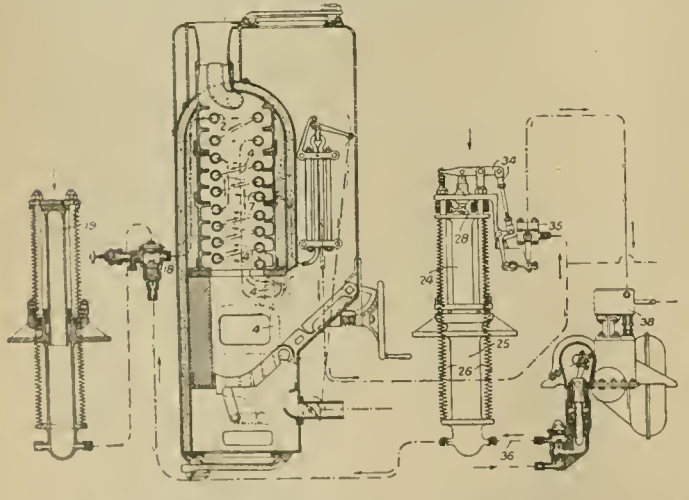
A hollow dead plate or air-distributing box extends downwardly from the fuel opening of internally-fired steam boilers to the grate, air being supplied to fuel resting against the dead plate through perforations or between bars forming the front of the dead plate. As shown in Figs. 3 and 4, the hollow dead plate is constituted by short, steeply sloping bars 8 resting at their lower ends on a bearer 13. At the sides of the fire-box 1 are hollow baffles and air casings. Valves 3 control the supply of air passing above and below the grate and to the hollow dead plate. The depending diaphragms 17 distribute the flow of air over the grate. The adjustable diaphragm 19, Fig. 5, guides the air from the ash-pit to the hollow dead plate, which is in this case a perforated casting 18.



No. 183,231. Steam-generators.

Brunet, M. and Maison Detilleux Soc. Anon., 84, *Rue Sur-la-Fontaine, Liège, Belgium. April* 18, 1921, *No.* 11224. [*Class* 123 (*ii*).]

The valve 35 controlling the steam supply to the feed-pump 38 of an instantaneous generator is opened and closed by the movement of a rod 24 sliding in a cylinder 25 and acted upon by the pressure in the feed-delivery pipe 36 so that when the pressure rises, the rod is forced outwardly against the resistance of springs 26, and by contacting with a member 28 moves levers 34 connected to the steam-

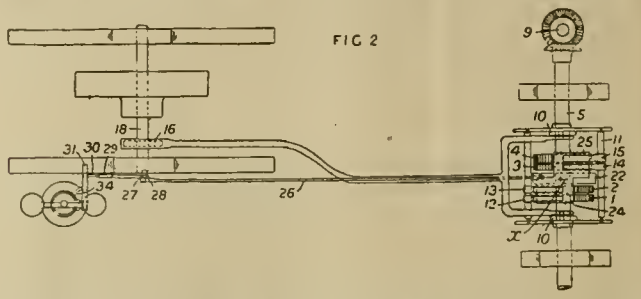


valve. To allow adjustment of the opening of the valve, the member 28 is formed in two parts, which are connected so that the length of the member may be varied. An hydraulic accumulator 19 is connected to the feed-pipe beyond the check-valve 18 to allow the feed to enter the generator without shock when starting. The feed passes from the feed-heating elements 2 downwards through a pipe 4, which is preferably bent around the door of the furnace, to the steam-generating elements 4¹. The steam is superheated in intermediate elements 7.

No. 183,310. Turbines, &c.

Dunne, J. J., White's Cross, Cork. May 28, 1921, *No.* 14897. [*Class* 110 (*iii*).]

Regulating.—The inlet-valve opening of a water turbine is governor-controlled. Pawls 12...15 are mounted on a frame 10, 11, oscillated continuously on a shaft 5 from an eccentric 16 on the main shaft 18, and they rest normally on a shield 24, 25, fastened to a wheel 22, which can be rotated on the shaft 5 by the movement of a governor sleeve 34 through a link-and-lever system 26...31. Right and left hand ratchet-wheels 1...4 are fixed on the shaft 5 on either



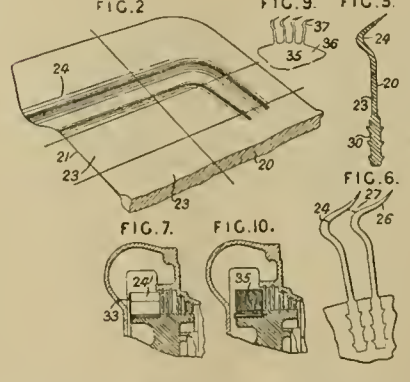
side of the wheel 22, underneath the shield 24, 25. Increase in speed lifts the governor sleeve 34, and turns the wheel 22 in the direction *x*; this removes the shield 24 from under the right-hand pawls, which engage the ratchet-wheels 1, 2 and rotate the shaft 5, and with it the valve-rod 9 to close the valve. Decrease in speed from the normal gives opposite rotation of the valve-rod 9 through the wheels 3, 4.

Reference has been directed by the Comptroller to Specifications 5274/79, 6855/07, *and* 10593/08.

No. 183,429. Turbines.

Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster.*—(*Assignees of Kasley, A. T.*; 511, *Saude Avenue, Essington, Pennsylvania, U.S.A.*) *May* 29, 1922, *No.* 15076. *Convention date, July* 21, 1921. *Not yet accepted. Abridged as open to inspection under Sect.* 91 *of the Act.* [*Class* 110 (*iii*).]

Relates to improvements in the low-pressure reaction blading for the last row of moving blades described in Specification 182,775, which blading receives elastic fluid axially and discharges it peripherally, or peripherally and laterally, at a small angle. The improved blade 20, Figs. 2 and 5, comprises an inner radial portion 23 with inlet edge 21 and an outer hook portion 24 extending at right-angles from the edge 21 and around the curved rear corner, the discharge edge of the portion 24 being arranged at a small angle. The blades may be secured to the rotor by a multiple dovetail connection 30. The centre of gravity of the blade falls within the radial portion 23. In a modification designed to secure greater expansion, the outer portions 26 of the hook portions 24, Fig. 6, define expanding passages 27. The hook portion 24¹, Fig. 7, may extend straight across the blade, the outer edges being blocked by a plate 33. A laminated construction of blade is shown in Fig. 10, each lamination 35, Fig. 9, being punched from sheet metal and comprising a hub portion 36 integral with the blade 37 and adapted to be secured to the rotor. Alternatively, the lamination may be made in sections secured by dovetail connections.



OFFICIAL NOTICES.

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THE Owners of British Patent No. 150301, relating to a "Method of, and Apparatus for, Lubricating Couplings," are desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above invention either by sale of the Patent rights or by the grant of a licence or licences to manufacture under royalty. Enquiries should be addressed to Messrs. Abel & Imray, Chartered Patent Agents, 30, Southampton Buildings, London, W.C.2.

The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION CARGO HANDLING APPLIANCES

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

Vol. XLV. No. 542. November, 1922.

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Mr. Geo. N. McLenahan, M.E., has been appointed Superintendent Engineer of the Dundalk & Newry Steam Packet Company Limited. The duties have hitherto been discharged by outside engineers. Mr. McLenahan has been in the service of the company for some years.

Mr. Colin F. Macdonald, for a number of years a surveyor to Lloyd's Register of Shipping at the Port of New York, has been appointed Chief Inspector for the New York district of the Employers' Liability Assurance Corporation Limited, London.

The following scholarships in marine engineering have been awarded by the Council of the Institution of Naval Architects. The Parsons Scholarship (£150 per annum) to Mr. C. E. Moffatt, of H.M. Dockyard, Devonport; and the John Brown Scholarship (£150 per annum) to Mr. Donald Campbell, of the Fairfield Shipbuilding & Engineering Company, Govan, Glasgow. The Elgar Scholarship in Naval Architecture (1922) has been awarded by the Council of the Institution to Mr. William Sprague, of H.M. Dockyard, Devonport, and the Earl of Durham prize to Mr. F. F. Crocombe, of H.M. Dockyard, Portsmouth.

Alderman Sir John Maccoy has been chosen Mayor-elect of Gateshead for the seventh time. He is one of the best-known figures in the shipping life of Tyneside. Earlier in his career Sir John was superintendent engineer for the Prince Line, and was for many years a partner in the firm of Lunn & Maccoy, shipowners, Newcastle. He received his knighthood at the beginning of this year.

Mr. Andrew Macfarlane, Consulting Engineer and Naval Architect, of the firm of Macfarlane, Garmay & Co., 32, Broadway, New York City, died recently at his home, 86, Prospect Park, Brooklyn. He was born in Sunderland, England, and served his engineering apprenticeship with William Doxford & Sons, Sunderland, later going to Parsons Marine Steam Turbine Company, Wallsend, and the Wallsend Slipway & Engineering Company.

James C. Corrigan, of Hampstead Road, Elm Park, Liverpool, the senior Second Engineer of the White Star liner *Adriatic*, has been presented with a beautiful gold watch by the management of the White Star Line, in recognition of the bravery and courage he displayed during the explosion on that steamer a short time ago. The inscription on the watch reads: "Presented to Mr. J. C. Corrigan by the managers of the White Star Line in recognition of his conspicuous bravery on board the *Adriatic*, August 11, 1922."

The death occurred recently at Great Crosby, Liverpool, of Mr. John Heggie, who was formerly Chief Engineer in the service of the Cunard Steam Ship Company and retired about a year ago. Mr. Heggie joined the Cunard Company as an apprentice engineer in 1873, and had been in their service about 48 years. He was Chief Engineer of the *Caronia* while she was a transport during the late war, and received a medal from the King for services rendered in connection with a serious fire in the bunkers whilst the vessel was off the coast of East Africa.

Mr. Robert George Carr, on the occasion of his retirement as Assistant Superintendent Engineer from the firm of Macandrews & Co. Limited, shipowners, Laurence Pountney Hill, E.C., was, on September 30, presented with 100 guineas from his colleagues ashore and afloat as a mark of the esteem and respect in which he is held by all those who have been associated with him during the period of almost 40 years' service. Mr. Carr joined the firm of John Hall, Junr., & Co. Limited, as far back as 1885 as third engineer in one of the company's steamers. Eventually he rose to the position of Chief Engineer, and in 1901 he came ashore to take up the position of assistant to the then Superintendent Engineer, Mr. George Paul, whom he afterwards succeeded. On the fusion of the firm with Macandrews & Co. a few years ago Mr. Carr became assistant to Mr. J. D. Bartlett, who had been their superintendent for many years.

After an active career of 54 years, Mr. Wm. John Sergent, Superintendent Engineer of the Canadian Pacific Steamships Limited, recently retired from that position. As a token of the esteem and respect in which he is held, Mr. Sergent was, on October 4, made the recipient of a series of very handsome presents on board the C.P. liner *Montcalm*, at Liverpool. These gifts were presented by the Liverpool Manager of the Company, Captain J. V. Forster, on behalf of the seagoing and shore staffs of the Canadian Pacific Steamships Limited and the Canadian Pacific Railroad Company. Mr. Sergent, who was appointed successor to Mr. William Wallace, the Superintendent Engineer of the Allan Line in 1899, was largely instrumental in the introduction of steam turbines in the famous *Victorian* and *Virginian* as far back as 1904. Two further very fine vessels with which Mr. Sergent was associated were the *Alsatian* and *Calgarian*. Since the fusion of the Allan and Canadian Pacific Companies, several very fine oil-burning vessels had also been built, notable among which is the *Empress of Canada*.

EDITORIAL.

MOTORSHIP PROGRESS.

DURING the last few years of marine Diesel engine development, the steady progress of this prime mover in its application to the various types of vessel has won over, as it were, many who had not hitherto reposed full confidence in this type of marine engine. How gradual has been this progress and how deeply rooted the feeling of bias against the Diesel engine in many quarters may be realised when we find that in the preface to his latest book—which, it should be mentioned deals with the Diesel engine—one of our most prolific writers on marine engineering confesses to a recent and complete "conversion" to the Diesel belief and asks his readers to accept his latest work as something in the nature of a missionary effort on behalf of the marine Diesel engine. We had just gone down to press with our last issue when we learned of the latest and, undoubtedly, the most noteworthy advance so far made in the application of the Diesel engine to marine propulsion. We refer to the order placed by the Union Steamship Company of New Zealand with the Fairfield Shipbuilding and Engineering Company Limited, of Govan, Glasgow, for a new 600 ft., 18 knot Diesel-driven passenger liner.

The very marked advance which the new vessel represents on any previous motorship will be gathered from a brief description of the more outstanding features of the ship and her propelling machinery. As already stated, the new liner will have a length of 600 ft. and a service speed of 18 knots, with a gross tonnage of about 20,000 tons. The propelling machinery, it is understood, will comprise four six-cylinder two-cycle Fairfield-Sulzer engines, each set developing 3,000 b.h.p. at 135 r.p.m., or an aggregate b.h.p. of 12,000. These main engines will be constructed at Glasgow by the Fairfield Company under license from Sulzer Brothers, and the cylinders will have a diameter of 27 in. and a piston stroke of 39 in. Scavenging air will be supplied by three electrically-driven turbo-blowers, which will be designed of such capacity that two will supply all the air required by all four main engines. Included in the auxiliary machinery equipment will be four two-cycle Sulzer engines developing 400 b.h.p. each, at 200 r.p.m. Each of these units will be direct coupled to an electric generator and will be constructed by Sulzer Brothers at Winterthur. The new liner is intended for the New Zealand-Vancouver service, and reference to the map will show that the run is one which calls for endurance and reliability on the part of the propelling machinery.

There are one or two factors in connection with the new liner which are worthy of mention. Primarily, it should be noted, that her aggregate of 12,000 b.h.p. represents about twice as much as that developed in any other motorship afloat. We are told that the decision to adopt this particular type of propelling machinery was the outcome of the most careful consideration on the part of the Union Steamship Company, Sulzer Brothers and the Fairfield Company; that, of course, may safely be taken for granted. Nevertheless, it had hitherto been generally believed among engineers, and even among acknowledged advocates of the Diesel engine, that, for vessels of this speed and size, the internal-combustion engine, in its present state of development, was unsuitable, because of the large increase in the number of cylinders and shafts and the lower mechanical efficiency involved in developing the high aggregate b.h.p. It is but a few weeks since it was suggested at the British Association meetings, that the future scope of the Diesel engine was likely to be confined to competition with the triple-expansion steam engine in cargo vessels which, it was pointed out, constitute 90 per cent. of the total tonnage owned in this country. Presumably the needs of the larger and faster types of vessel, comprising the remaining 10 per cent., would be met by the steam turbine and reduction gears. Exactly what part the recent difficulties experienced with double-reduction gears have played in influencing the owners and builders in this case to adopt the Diesel engine for a high-powered liner, it is not possible to estimate. That these difficulties have not constituted an altogether dormant factor in the machinery discussions may be reasonably assumed. It is, we feel, no reflection on the Sulzer engine to say that there are to-day other types of Diesel engine with which more extended sea experience has been gained, and which might reasonably claim to have reached a stage of more complete development, but the fact that the Fairfield Company should have decided, after extended investigation, to adopt the Sulzer engine for power requirements which represent not merely a progressive step, but actually a radical departure from anything hitherto demanded of any marine Diesel engine, may be taken as a measure of the confidence which the Fairfield Company repose in the Sulzer engine.

That the step is a bold one and contains certain elements bordering on the experimental, cannot be gainsaid. The Fairfield Company have been pioneers in more than one phase of the development of methods of marine propulsion, and in this latest phase it is safe to say that their scope has never been greater. We can hardly doubt for a moment that the new vessel will be a success and it is equally certain that her progress will be watched by owners and marine engineers the world over with the very keenest interest.

THE SHIPBUILDING SITUATION.

THE statistics issued by *Lloyd's Register of Shipping* for the quarter ended September 30 reveal some good features, and others which are not so good. Taking first of all the United Kingdom we find that at the end of the quarter there were 331 vessels of 1,617,045 gross tons under construction, as compared with 390 vessels of 1,919,504 gross tons in the previous quarter, and 700 vessels of 3,282,972 gross tons twelve months ago. If we deduct from the tonnage under construction 419,000 tons on which work has been suspended, we find that the total tonnage under actual construction in the United Kingdom yards is only 1,198,000 tons, a figure which falls short of the average for the twelve months immediately preceding the war by no less than 692,000 tons. A significant fact can be developed if we take the returns for the quarter ended June 30, 1921, which showed 3,530,047 tons under construction. A comparison of these figures with those for the present quarter shows a falling off of no less than 2,332,000 tons, or, in other words, the productive capacity of our shipyards is only one-third utilised to-day.

It has been said that figures may be made to prove anything, and if we view these statistics as they are the position is admittedly bad. There is, however, a brighter side to the shipbuilding position, and an analysis of the complete returns shows unmistakable signs of a slight improvement. An examination of the figures for tonnage launched and commenced during the quarter under review will show that from British yards there have been launched 307,232 tons, or an increase of 158,316 tons on the previous quarter. New tonnage laid down reached the figure of 82,428 tons, or an increase of 13,551 tons—a hopeful sign.

A review of the shipbuilding position abroad shows that there, conditions are certainly not better than in the United Kingdom. It is seen that the total tonnage under construction amounted to 1,085,511 tons, or actually less than that under construction in the United Kingdom by fully half a million tons, from which we may assume that we are receiving a fair share of what little new tonnage there is offered. The total tonnage commenced in the world during the quarter was 187,527 tons, of which our share—82,428 tons—represents

almost one-half. It is interesting, as showing the gradual upward tendency of the motorship, to compare the relative tonnage figures as commenced during the first three quarters of the present year, and in the following table we give for the principal countries such figures :—

Country.	1st Quarter.		2nd Quarter.		3rd Quarter.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
United Kingdom—						
Steamers	18	49,208	12	37,177	30	66,908
Motor vessels	1	100	5	810	3	15,200
Denmark—						
Steamers	1	550	1	1,050	1	960
Motor vessels	—	—	1	2,925	3	7,695
France—						
Steamers	6	29,587	11	23,369	2	5,800
Motor vessels	—	—	—	—	—	—
Holland—						
Steamers	1	2,000	3	12,100	—	—
Motor vessels	—	—	1	5,259	—	—
Italy—						
Steamers	1	5,300	2	200	—	—
Motor vessels	—	—	—	—	—	—
Japan—						
Steamers	1	3,800	3	13,990	10	16,120
Motor vessels	1	310	—	—	—	—
Norway—						
Steamers	—	—	3	3,389	5	6,689
Motor vessels	—	—	—	—	—	—
Sweden—						
Steamers	—	—	—	—	1	859
Motor vessels	—	—	1	130	2	13,260
America—						
Steamers	6	10,400	8	39,200	10	48,400
Motor vessels	3	800	2	1,498	—	—

Taking all countries, the total steamer and motor tonnages on which work was commenced during each of the three quarters of the present year were as follows :—

	1st Quarter. Tons.	2nd Quarter. Tons.	3rd Quarter. Tons.
Steam	114,725	133,416	148,297
Motor	1,310	10,866	36,875
Motor percentage	1·17	8·15	24·8

These figures, when taken in conjunction with the first table, show the unmistakable advance of the motorship, and recent events have been such as to foster the belief that the next quarterly statistics will show an even higher proportion of motor to steam then the 25 per cent. above. The total steamer tonnage under construction in the world was, from the latest returns, 2,439,177 tons, while the total motor tonnage was 241,622 tons, or practically 10 per cent.

It is perhaps doubtful whether at any previous time in the history of marine engineering a greater tribute to the enterprise of our engineering and shipbuilding establishments could be found than in the returns for motor vessels under construction. In motorship construction we lead the world with a total of 126,437 tons, Sweden is second with a total of 38,565 tons, Denmark third with a total of 22,910 tons, and Italy fourth with 20,298 tons. Of even greater significance is the fact that America, a country with great maritime ambitions, has but one motor vessel under construction and the tonnage of that vessel is only 360 tons.

While there is nothing in the returns to justify undue optimism, there can be no doubt that the outlook for the future is more hopeful. There are many inquiries circulating at present for new tonnage of quite satisfactory dimensions, and provided the wages negotiations at present in progress reach a satisfactory adjustment and that industrial peace is preserved, the shipbuilding and marine engineering industries may safely be said to have passed their darkest period.

INDUSTRIAL METHOD AND SERVICE.

IN recent years we have almost subconsciously become influenced to look to the annual addresses delivered by the presidents of our several Institutions representing the great shipbuilding and marine engineering industries for something distinctly above the average and containing expressions of opinion of considerable significance to the industries concerned. That we do not look to such sources in vain has been amply demonstrated time and again, and it would be difficult to quote a better example than that offered by Sir George Goodwin's address to the Institute of Marine Engineers, with which we dealt in our last issue. The address which we propose to discuss briefly here is not any the less noteworthy in that the subject matter chosen by the President lies somewhat outside the province usually associated with such addresses. We refer to the presidential address delivered by Sir Archibald C. Ross, K.B.E., M.Inst.C.E., on October 20, before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne.

Sir Archibald confessed to a certain feeling of trepidation in touching on some of the problems which, as he was aware, were somewhat outside the usual run of subjects dealt with by presidents in his position. The very direct influence, however, which such problems have on the various professions of engineering, shipbuilding and shipowning will, we feel, constitute adequate justification for the apparent irregularity. The great changes which had taken place in the methods of conducting modern industrial establishments were reviewed and the opinion was expressed that should an employer of some 70 years ago endeavour to conduct a modern establishment on lines which were accepted at that period, his success would be extremely problematical.

The President, dealing with the vastly changed industrial conditions of to-day, points out that there are several important factors worthy of consideration, and these he collects under the headings of Method and Service. By method he includes organisation, purchasing, selling, commercial capability, manufacture, education and welfare ; and under the heading of Service—which does not imply anything servile or feudal—is embraced merely that honest inclination and desire to do one's best at work in the interests of the community and, what is more important, doing it. Discussing method, Sir Archibald suggests that there are many instances in the world of manufacture where a frank disclosure of the minor difficulties of one individual manufacturer has had beneficial results on the industry as a whole. The case of the recent difficulties experinced with double-reduction gears is quoted, and the fact that the engineer and metallurgist have been brought together to discuss the problem in open forum, is taken to show the importance of the mutual exchange of knowledge and experience. It is the President's opinion that the many successful performances of geared turbines have been somewhat unfairly swamped by the prominence given to the few failures, and it is his hope that the system of double-reduction gears will yet be vindicated and reinstated in the confidence of the shipowner. On the question of "Service," Sir Archibald hesitates to elaborate on certain features in connection with Labour which are highly controversial. In arriving at mutual agreement without the interference of outside parties, such agreement will only be possible by better faith and trust between management and workers and between the existing combinations of federations and associations and the trade unions.

We congratulate the President on the very able and well-reasoned handling of a subject which is manifestly complex. It has come at a very opportune time when, as we all hope, the trade barometer has left the lowest point to begin a gradual ascent, and when, as we are all agreed, a return to more prosperous times is dependent upon nothing more than on industrial harmony and peace.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

The Superintendent Engineer's Pocket Data Book. By the Superintendent Engineer of the Royal Mail Steam Packet Company. Glasgow: James Munro & Co. Ltd. 4¼ in. × 6½ in. × ½ in. 228 pages. Price 7s. 6d. net.

In this little book the author has provided a convenient and ready means of collating complete information on the ship, and such associated items as main engines, main Diesel engines, auxiliary Diesel engines, boilers, condensers, propellers, shafting and funnels, consumption, speed, &c., personnel; deck, electrical and refrigeration machinery, cargo, passengers, bunkers, tanks, &c. It is with a certain sense of surprise that we find, in a book which is otherwise very complete and manifests great care in its compilation, no reference to the steam turbine and reduction gears. Such matters as axial and radial blade clearances, number of impulse or reaction stages, helical angles, tooth pitches, &c., are not outside the concern of many superintendents. With this exception, the work is highly creditable, and we can confidently recommend it to the superintendent and also the chief engineer.

The Electrical Handling of Materials. By H. H. Broughton, M.I.Mech.E., M.I.E.E. London: Benn Brothers Limited, 8, Bouverie Street, E.C.4. 8¼ in. × 10½ in. × 1⅛ in. 336 + xvi pages. Many folding plates and illustrations. Price 50s.

This book, which is Vol. III of a four-volume series, deals with almost every type of electric crane in general use to-day. The work has been brought right up to date and representative types of crane as used in British and foreign shipyards are fully described and illustrated. In addition to a comprehensive description of the cranes proper, a vast amount of information is given relative to variable speed lifting and associated mechanisms. The drawings and other illustrations have been excellently reproduced and altogether, the book may be regarded as a most complete and up-to-date treatise on the subject.

Marine Power Plant. By Lawrence B. Chapman. London: McGraw-Hill Book Company Inc., 6 and 8, Bouverie Street, E.C.4. 6 in. × 9 in. × 1 in. 320 + viii pp. Numerous illustrations. Price 20s.

The author has endeavoured to place before the student of naval architecture and marine engineering the elements of the thermodynamics of marine engines and to give him a complete grasp of the arrangement and function of almost every type of propelling and auxiliary machinery. It is the practice at Lehigh University, where the author is Professor of Naval Architecture, to begin the study of marine engineering by a course in thermodynamics, and thereafter to proceed to sea for the summer months, finally following up with a thorough and detailed study of all marine machinery. The several types of propelling machinery, including reciprocating, direct and geared turbine and Diesel engines, as well as turbo- and Diesel-electric machinery are discussed in a lucid and practical manner. In his statement that "most of the merchant ships fitted with double-reduction gears to-day are operating perfectly," the author is likely to meet contradiction from certain quarters. As a thoroughly practical introduction to the study of marine engineering in all its various aspects, we can confidently recommend this book.

Boiler Feed Water. By Percy G. Jackson, F.I.C. London: Charles Griffin & Co. Limited, Strand, W.C. 2. Second Edition, 1922. 4¾ in. × 7½ in. × ½ in. 143 × xi pages. Numerous Illustrations. Price 5s.

Originally published three years ago this little book has been revised and enlarged, the principal additions consisting of a chapter dealing with boiler control and a fuller description of water-softening plants and processes. It is becoming increasingly recognised that the control of a boiler plant calls for the exercise of a considerable amount of care and knowledge, and the failure to apply these qualities may result in the reduced life of the plant and high maintenance costs. The author discusses the constituents and general characteristics of an infinite variety of feed-waters, and means of detecting and eliminating undesirable constituents are suggested. Scale, corrosion, priming and associated phenomena are dealt with, and a very lucid description of the various methods of feed water analysis is given. It is felt that the questions of softening and the selection of softening plant, inasmuch as these occupy almost one-third of the book, have perhaps been given undue prominence. There is a soundly practical flavour about the book which we like, and we feel that by its perusal the boiler-house superintendent, and the marine engineer may arrive at a fuller understanding of the science of boiler management.

TRADE PUBLICATIONS.

Fiat Marine Engines.—Fiat Motors Limited, of 43-44, Albemarle Street, W.1, and of Wembley, Middlesex, have forwarded to us two specifications illustrating and describing their motor boat engines. Model 51A, of 10-12-h.p., which was priced at £180, has now been reduced to £150; and model 53A, of 25-h.p., is now listed at £220 instead of £250, as formerly.

Electric Motors.—The English Electric Company Limited, Queen's House, Kingsway, London, W.C.2, have published a booklet, No. 304, on the "English Electric Industrial Motor." These motors are made in six types and for direct and alternating current. The booklet is well illustrated and gives a full description of the constructive features and methods of ventilation.

Ironclad Switchgear Company Limited.—We are advised that the new London address of this company is 23, Queen Anne's Gate, Westminster, S.W.1. The London office of the company will deal with inquiries and orders emanating from South Wales, Midlands, East Coast, Southern Counties, and Overseas, and arrangements have also been made for the preparation of large London stocks.

Marine Diesel Engines.—A series of diagrams has been received from Burmeister & Wain, Copenhagen, illustrating the number of full-powered Diesel motorships actually in service at three periods: December, 1921, February and April, 1922, respectively. These diagrams include every type of engine and demonstrate the present preponderance in tonnage of vessels fitted with Burmeister & Wain four-cycle engines.

Electrically-driven Rolling Mill.—The electrical installation of the reversing rolling-mill at the Skinningrove Iron Works is the subject of the English Electric Company Limited's booklet, No. 319. The mill has an output of 45 tons per hour and includes a 36-in. cogging mill, driven by a 12,000-h.p. reversing motor, and 36-in. roughing and finishing mills, which are driven by a 19,000-h.p. reversing motor. A full description of the installation is given, together with illustrations and diagrams.

THE REVIVAL OF CAST IRON—II.

By "Exaggerous."

In the first article the writer attempted to review the past history of cast-iron, and in this article he will strive to record what the world is doing in order to bring the metal into line with other metals. To the engineer this may sound dull. "Cast-iron is cast-iron," he says, "so why all this fuss about it?" Anything to which we are thoroughly accustomed may appear dull, and the engineer is too used to cast-iron being cast-iron to feel any excitement about it. Tell him, however, that "steel is steel," and he will immediately pin you down by asking to what type and class of steel you refer.

Before long he will think the same about cast-iron and will classify it by as many qualities as the scientists have isolated. Already we have several peculiar varieties exhibiting properties of their own, and which, in all probability, may lead us to the track of certain definite series.

Semi-Steel Phenomena.

Take semi-steel as an example, and we find we are up against some peculiar phenomena. Semi-steel or toughened cast-iron is made by melting in the ordinary way in the cupola a mixture of pig-iron, scrap-iron and steel—the latter being present in any amount from, say, 5 to 50 per cent. One or two little precautions in cupola practice are necessary, and a dash of ferro-manganese, but, altogether, it is a simple proposition. It may be appropriately mentioned here that many foundrymen in the past have avoided steel as they avoid poison, the result being a lack of progress and knowledge along these lines.

As a matter of fact, this so-called semi-steel is a remarkable metal, and much remains to be discovered about it before we can ascertain its proper position in commerce. Cast-iron, as we all know, contains some of its carbon combined with the metal, and the remainder "loose" within it in the form of flakes or plates. This "loose" carbon is so loose that when the metal is machined it shakes out and soils the hands of anyone touching it.

It should be obvious to the most unscientific person that if these flakes of carbon are loose in the metal their size and distribution must be of importance in determining the physical properties of the material. Consequently, any element or any process which tends to control the size and distribution of the free carbon will be of immense importance to the future of cast-iron. When steel is added to the cupola, as before described, it does not arrive at the tapping-hole in the state it entered at the charging door. Instead, it has absorbed carbon from the coke and turned itself into something similar to cast-iron.

Scientific Aspect.

The matter does not finish here, for the cast-iron or semi-steel thus produced is different to ordinary cast-iron made from a no-steel mixture. *How* different the writer is not prepared to say, but different it is. The main difference is that the free carbon is frequently in a finer state of division than it is in ordinary cast-iron. Another difference is that the metal is softer than would be expected from its composition, so much so that with a silicon-content below 1 per cent. the metal is still perfectly soft and machineable. The scientific aspect of semi-steel is even more important and interesting for this reason, namely, its critical points appear to be different to those of non-steel iron.

When an alloy is cooling from its molten state to a cold solid, certain critical points are passed, upon which depend the final condition of the metal. Quench a piece of hot steel in water and allow another piece to cool slowly in the furnace, and the two steels will be different. You have rushed one through its critical ranges, while you have allowed the other to have the full benefit of each range. Cast-iron has certain points which determine its final qualities. The position (*i.e.*, the temperature) at which each point occurs is determined by the composition of the sample. But two samples of similar composition, one being non-steel metal and the other semi-steel, do not appear to possess the same critical points, or, at any rate, the points or ranges do not occur similarly or simultaneously in each sample.

It would be out of place to attempt any scientific dissertation upon critical points, and it must suffice to say that semi-steel has, like cast-iron, not yet "grown up." The writer believes that some makers of Diesel and internal-combustion engine castings are pinning their faith upon this metal, and it is to be hoped that they are not merely making it in a rule-of-thumb manner, but are trying to understand it.

Refined Cast Iron.

There is another form of semi-steel—it is frequently referred to as "refined" cast-iron. This is generally melted in an electric or air furnace other than a cupola. Why it should be called "refined" is not very clear. Refining to the ordinary mind means the clearing out of deleterious impurities. But if you burnt out the tin and zinc from ordinary gunmetal you would not call it "refined" gunmetal, although, if you did it properly, you might call it refined copper. However, in the case of cast-iron, some bright-thinking individual took it into his head to call everything in it an impurity—hence, "refined" cast-iron is iron with less of carbon, sulphur, phosphorus, manganese and silicon, of one or all, as the case may be, than in ordinary cast-iron.

Curiously enough, if you "refine" iron by blowing out these things in a cuploa, the practice is universally condemned by every right-minded person, but if you do it in an open-hearth furnace or by any other means than in a cupola you are applauded for producing "refined" cast-iron.

Undoubtedly this refining process contains great possibilities, though its application at the moment is limited by lack of power to control the process and lack of knowledge as to what we want to aim at.

A cast-iron containing less than 2·8 per cent. of carbon may be a notable achievement—this has yet to be proved—but certainly it is a queer proposition in the foundry. It has to be cast at temperatures near those of the steel foundry, and the metal has a nasty little way of eating into the cores and parts of the mould so as frequently to render it impossible to "clean" the casting. These difficulties will be got over as time passes and new moulding materials are discovered, but in any case the troubles experienced in the making of steel castings will be met with in any exceedingly high-temperature work. Undoubtedly this low-carbon cast-iron may have a great future for cylinder liners and other plain castings, but for more intricate work it appears likely that steel will be as good and possibly less expensive.

Several firms are engaged in producing iron of this quality, and its main use at present would appear to be simply and purely as a pig-iron to mix with other irons. The process is talked about as if it were under complete control and that any iron of any composition can be produced at will. The writer thinks this remains to be proved and that its metallurgical

"balance" is not dissimilar to that of the cupola product. Either the makers lack originality or else the fact is as stated—most probably the latter.

Centrifugal Casting.

An extremely interesting venture is the cast-iron produced by the centrifugal-casting process. In this process there happen two phenomena, and possibly only one of them is important. The spinning of the metal causes the impurities to segregate at the surfaces of the casting, where they may be machined off afterwards, leaving the purer metal behind. This is interesting, but does not appear to the author as being particularly valuable. What does appear to be important, however, is the fact that the movement of the metal causes a breaking up of the graphitic flakes and general structure, so that the microsection of centrifugally cast-iron is very different from that of ordinary cast-iron. We should like to know a great deal more about the properties of this material, also whether its possibilities are being scientifically examined. The mere fact of being able to make common iron into good strong castings by this process is one thing, but whether the breaking up of the graphite in really good iron would produce a yet more superior product does not appear to be known.

Here, again, the process can be applied to plain castings only, and an intricate one would not appear to benefit even if it could be made at all.

Use of the Electric Furnace.

Abroad more than in this country cast-iron is being made by the help of an electric furnace. One process is to tap the metal from the cupola into the electric furnace and there superheat it and, if necessary, "refine" it. The trouble about the procedure is, as always, lack of knowledge. If the cupola metal is anything the cupola chooses to give—and this is frequently the case—then it is not a great advantage to superheat it or refine it. An instance of this may be got by reading reports of the process, where the foundries in question have improved their cupola metal by means of the superheating, but where the final metal is no better than could have been obtained by the cupola alone had it been properly understood and properly charged.

Another process is to melt down a charge of steel, scrap and pig-iron in the electric furnace alone. Obviously there are enormous possibilities attached to such procedure, and prolonged research along these lines would be almost certainly productive of improved cast-iron. As to whether the metal would be a commercial proposition is another matter, and, so far as this country is concerned, it seems highly improbable owing to the cost of the operations involved. Electric furnaces are not particularly reliable, breakdowns are frequent, and repairs are expensive. Further, it is a serious matter for a breakdown to occur in a furnace full of semi-molten metal when the moulds are all ready for pouring—the writer has seen this happen with most disastrous results, financial and otherwise. Hence, apart from the cost of electric power, there are other serious considerations involved, although it is not to be denied that, metallurgically speaking, the process is ideal.

Cupola Practice.

The common (or garden) cupola melting is not yet defunct. It has been explained in the first portion of this article how wonderfully elastic is this type of furnace; indeed, it is due to its elasticity that the process has been degraded to the condition of being almost laughable to the scientific mind. Search as you may, you will not be successful in finding any precise reasons for the working of a cupola in any particular manner. You will find many opinions and many books of advice, but none of them are backed by figures and statistics.

The fact of the matter is that nobody has been able to spend the time and the money necessary for the solution of this problem. We have been able to work our cupola so that it did not play tricks with us more than about once in three months, and that is about as much as we can say. If you desire to make metal containing under 0·075 per cent. of sulphur, you will find that now and again you will fail in a most astonishing manner. Equally, if you desire metal containing more than 0·2 per cent. of sulphur, you will also fail quite frequently. The control of the carbon-content is even more elusive, and accurate analyses of the total carbon in your cast-iron will speedily prove that the control is more in the hands of the cupola than in your own.

Nowadays, however, there do exist firms who realise those things, and work is being done. The main trouble is that experimental work and commercial work cannot go hand in hand. The scientist who experiments on a casting that is required next week is asking for trouble, and the employer who expects him to be successful under such conditions is making an error of judgment. An experimental foundry is undoubtedly a large proposition, but it is a very necessary thing to have if progress is to be made.

Electric Furnace *versus* Cupola.

The firms using cupola-melted metal are, at the moment, having as great success with it as are those firms using the electric or air furnace process—this statement, of course, applies to firms making a range of castings and not to those who produce plain specialities. The fact that cupola-melted metal is holding its own should encourage research into the cupola process. There are many possibilities about it, and it is a commercial proposition which most of the other processes are not. In the days of keen competition, those who can control and understand their cupola practice have an enormous advantage over those who discarded the cupola for something more expensive.

No mention has been made of alloy cast-irons. The writer believes that in certain directions research is taking place, but here, again, we should understand the carbon series before thinking we can get the best out of alloy additions.

The Need for Research.

The British Cast Iron Research Association is now established, and later on should give us a good lead and put us in the right directions. But it is disappointing to see that, instead of the foundries of the country flocking to the Association and insisting upon their needs being attended to, there are dozens and dozens of large and small foundries vacillating between joining and not joining. The result is that valuable time is being lost, and, instead of the Association assisting to make British cast-iron the best cast-iron of all, it is tied hand and foot for want of members, money and wholesale support.

Of course, bad trade is blamed for this lack of enthusiasm. Had we got splendid trade it is practically certain that the same thing would apply, only the excuse would be, "What do we need research for, trade is good enough?" The Association is making headway, however, and if it can get the funds, results will speedily come. There is also another Association interesting itself in cast-iron for internal-combustion engines, which has already done good work. Nevertheless, it seems a pity that there are two associations, and one would think that the whole of the resources of money and brains should be centred in one association under one head. Let it be most clearly understood that no research work can be expected to be so productive as that upon cast-iron, for the simple reason that up to now the ground is practically unexplored.

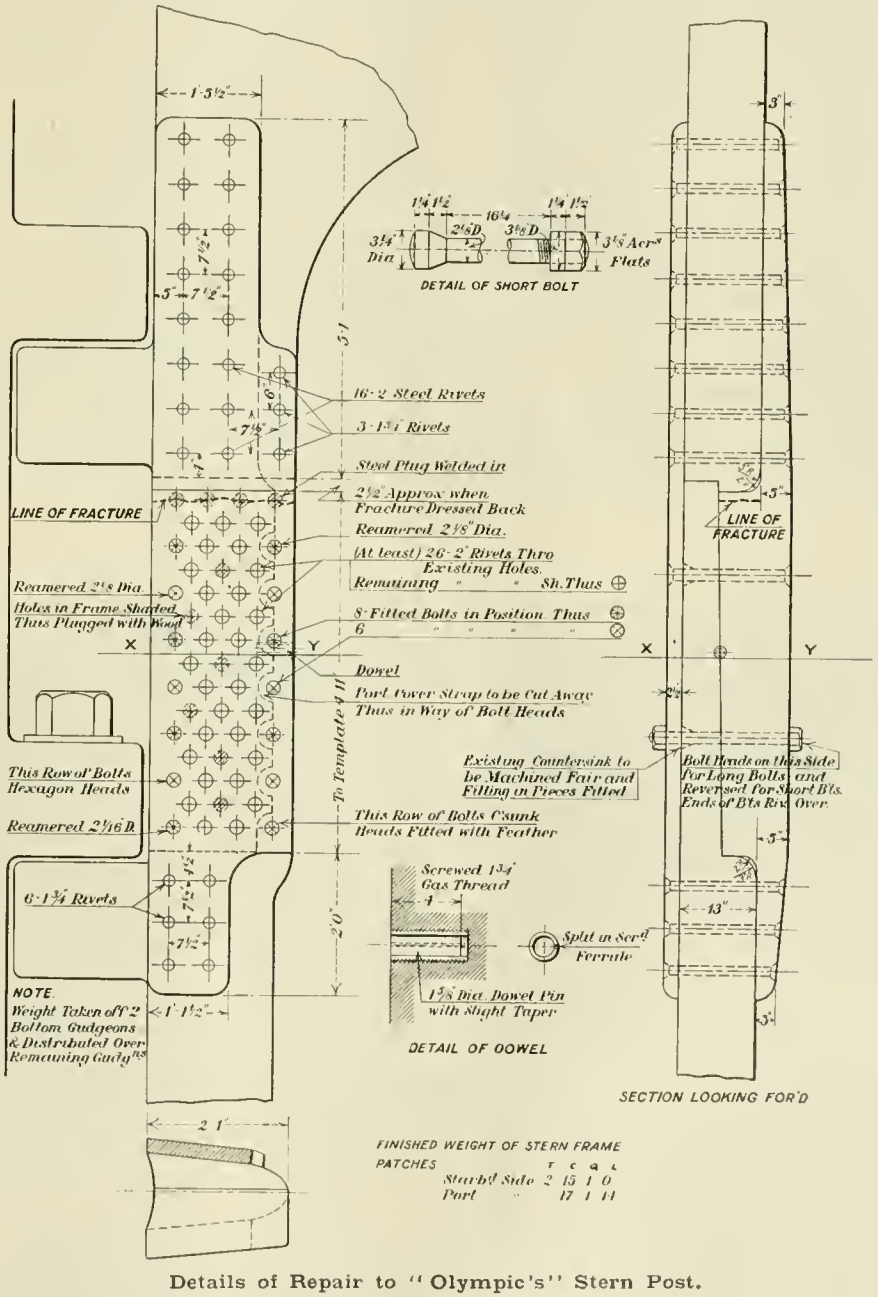
Much of the work that is being done is of a private nature, and we must "wait and see," but this article has indicated the various directions of the operations which are actually in progress—there may be others.

THE "OLYMPIC" STERN POST REPAIRS.

Some Interesting Particulars of Unique Stern Post Repair. Forgings supplied by the Darlington Forge Company, and Repairs carried out by Harland & Wolff Limited, Southampton.

We publish on pages 419–421 a series of photographs illustrating the damaged stern post of the White Star liner *Olympic* and showing, generally, the method of repair adopted in what constitutes undoubtedly the largest and most important repair of its kind ever undertaken. The *Olympic* is now some eleven years old and few vessels can lay claim to have performed in that time a greater measure of public service with a greater degree of reliability and unfailing punctuality. In addition to this fine record of public service, her distinguished war service, when engaged as a troopship during the gravest days of the submarine campaign, is now a matter of history and need not be recounted here. In a vessel of such gigantic dimensions as the *Olympic*, and carrying, as she does, several thousands of passengers, reliability is of vital importance, and it will readily be appreciated that any failure to adhere to scheduled sailing dates would not only occasion great inconvenience to the travelling public but would also involve the owners in considerable loss. Such unfailing regularity of sailing is not effected without the exercise of the utmost vigilance and attention to detail on the part of those responsible for every section of the vessel's appointments and equipment, and from no branch of the ship's *personnel* or the shore staff is greater vigilance demanded than from the engineering and associated technical services. During the course of periodical inspection on July 21 last the fracture, as shown on the illustrations, was discovered. This was, we believe, the first indication that fracture had actually taken place and there were no other preliminary indications such as vibration, straining, &c., so that, but for a regular system of inspection, this fracture might well have remained undiscovered, with very grave possibilities.

We produce on this page a drawing which, if taken in conjunction with the several photographs, will convey a clear understanding of the method of repair adopted. The position of the fracture, as will readily be seen, was in the upper half of the stern-frame at a point on the starboard side only a few inches lower than the upper extremity of the lower half scarph-piece. As was to be expected some slight evidences of chafing or riding were visible in way of the fracture, although there was nothing to indicate that the fracture was other than of very recent occurrence. In view of the heavy and reversed stresses borne by the stern post, and the vital importance of safety and reliability, it was decided not to weld the fracture but to fit specially heavy forged patches, riveted and bolted, as this was considered likely to constitute a more positive and permanent repair. To have renewed the upper half of the stern-frame would have involved the laying-off of the *Olympic* for some three or four months, a very serious inconvenience alike to the public and to the owners, at the height of the busy season.


LINE OF FRACTURE
16-2 Steel Rivets
3-1¾ Rivets
Steel Plug Welded in
2½" Approx when Fracture Dressed Back
Reamered 2⅛" Dia.
(At least) 26-2" Rivets Thro Existing Holes.
Remaining " " Sh. Thus
8 Fitted Bolts in Position Thus
6 " " " "
Dowel
Port Lower Strap to be Cut Away Thus in Way of Bolt Heads
Reamered 2⅛ Dia.
Holes in Frame Shaded Thus Plugged with Wood
This Row of Bolts Hexagon Heads
Reamered 2 1/16 D.
This Row of Bolts Crank Heads Fitted with Feather
6-1¾ Rivets
To Template 4' 11"
2'0"
NOTE. Weight Taken off 2 Bottom Gudgeons & Distributed Over Remaining Gudgs
DETAIL OF SHORT BOLT
DETAIL OF DOWEL
Screwed 1¾" Gas Thread
Split in Scr'd Ferrule
1⅞ Dia. Dowel Pin with Slight Taper
Existing Countersink to be Machined Fair and Filling in Pieces Fitted
Bolt Heads on this Side For Long Bolts and Reversed for Short Bts. Ends of Bts Rivd. Over
SECTION LOOKING FOR'D
FINISHED WEIGHT OF STERN FRAME PATCHES
Tons Cwts
Starb'd Side 2 15 1 0
Port " 17 1 11

Details of Repair to "Olympic's" Stern Post.

Repair Difficulties.

The greatest difficulty, perhaps, of the whole repair was associated with the lifting of the necessary templates. This operation was rendered particularly difficult, due to the fore and aft wedge shape of the external surface of the post, combined with the taper of the scarph. A further source of

difficulty was the rough eroded surface of the post, and, of course, the great length of the forging. Mr. Blaylock, of the Darlington Forge Company, personally supervised the making of these templates and the machining of the forgings, and much of the success and despatch of the repairs is due to the efficient manner in which these operations were carried out. It will be noted that on the port side of the post the patch or slab was of light uniform section but the starboard side forging was of massive construction and was so arranged as to carry the scarph portion which had separated through the line of the rivet holes.

Before proceeding to a detailed description of the repairs, we give below some leading times and weights associated with the repairs, and these figures will, we believe, be regarded as noteworthy.

July 24.—6·30 p.m. Fracture discovered.
July 25.—Pattern makers commenced making patterns.
July 27.—Forgings ordered from Darlington Forge Co.
August 2.—Smaller forging received at Southampton.
August 6.—Larger forging received at Southampton.
August 18.—Work completed.
Total time taken = 25 days.

	Tons.	cwts.
Weight of larger forging before drilling	3	1
Weight of larger forging after drilling	2	15
Weight of smaller forging before drilling	1	2
Weight of smaller forging after drilling	0	17

Some indication of the work involved in drilling will be seen from these figures as no less than 6 cwt. of metal was drilled in the case of the larger forging, and 5 cwt. in the case of the smaller forging. With a view to making as tight and efficient a fit as possible, both forgings were bedded down with the aid of red lead marking to a spot, metal-to-metal bearing. As will be readily appreciated the drilling of the forgings in place through the existing holes in the 13-in. thick post, called for the utmost care and delicacy in alignment. Only the minimum number of holes was drilled with the forgings in place, the remainder being pointed with the drill and the forgings removed to the drilling machines in the shop where greater speed and precision were possible.

The Repairs Detailed.

Details of the bolts and rivets are given on the drawing on page 417. All holes having been carefully drilled, several were reamered to $2\frac{1}{8}$ in. diameter for fitted bolts, while the rivets were so machined on the head as to fit well into the countersink. These 2-in. rivets were driven through from one side a tight fit, and, when fully home, the opposite protruding end was heated with an oxy-acetylene flame and riveted securely over in the usual way. With a view to facilitating the fitting, the width was kept down as much as possible and to make "assurance doubly sure" the long fitted bolts were introduced, in addition to the rivets shown. One dowel pin with a diameter of $1\frac{5}{8}$ in. was introduced between the fitted faces as shown. To prevent the ingress of water between the fitted faces the exposed landing edges of the forgings were sealed by electric welding, but it is to be noted that in no part of the repairs was electric welding used for strength purposes. The scheme of these repairs was planned by Mr. W. J. Willett Bruce, O.B.E., M.Eng., Superintending Engineer of the White Star Line, and executed under his direction, in conjunction with Mr. F. J. Blake, the local superintending engineer of the Line at Southampton, by Harland & Wolff, whose local manager, Mr. W. Moss, supervised the work on behalf of his firm. The whole undertaking was accomplished to the complete satisfaction of the Board of Trade, the underwriters' surveyors, and all concerned. We take this opportunity of placing on record our appreciation of the facilities placed at our disposal by the owners, and the very helpful information kindly furnished by Mr. W. J. Willett Bruce, O.B.E., M.Eng., Superintending Engineer of the Line, and by Mr. Moss and Mr. Blake, already referred to.

THE TWIN-SCREW MOTORSHIP "TENNESSEE," OF 11,000 TONS D.W.

The twin-screw motorship *Tennessee* is one of three sister ships which have been built and engined by Burmeister & Wain Limited, at Copenhagen, to the order of W. Wilhelmsen, of Tonsberg, Norway, the other vessels being the *Teneriffa* and *Thalatta*.

The vessel has been specially designed for long voyages, her oil fuel capacity being sufficient for a radius of over 30,000 miles. The principal particulars are as follows :—

Length, overall	444 ft. 4 in.
Length between perpendiculars	425 ft. 5½ in.
Breadth, moulded	55 ft.
Deadweight	11,000 tons.
Draught, loaded	29 ft.
Speed at sea, average	11½ knots.
Indicated horse-power, normal	3,100.
Fuel consumption per 24 hours, normal	10 tons.

The main propelling machinery, an illustration of which we publish on page 439, consists of two sets of Burmeister & Wain standard type, six cylinder four-cycle Diesel engines for twin-screw vessels. Particulars of these main engines are as follows :—

Cycle of operations	4-stroke.
Number of cylinders	6.
Diameter of cylinder	630 mm. (24$\frac{13}{16}$ in.).
Piston stroke	960 mm. (37$\frac{13}{16}$ in.).
Revolutions per minute	125.
Indicated horse-power	3,100.
Brake horse-power	2,400.

The main engines are of the short-stroke crosshead type fitted with forced lubrication. A three-stage air compressor for supplying the necessary air for injecting and atomising the fuel oil is fitted at the forward end of each engine.

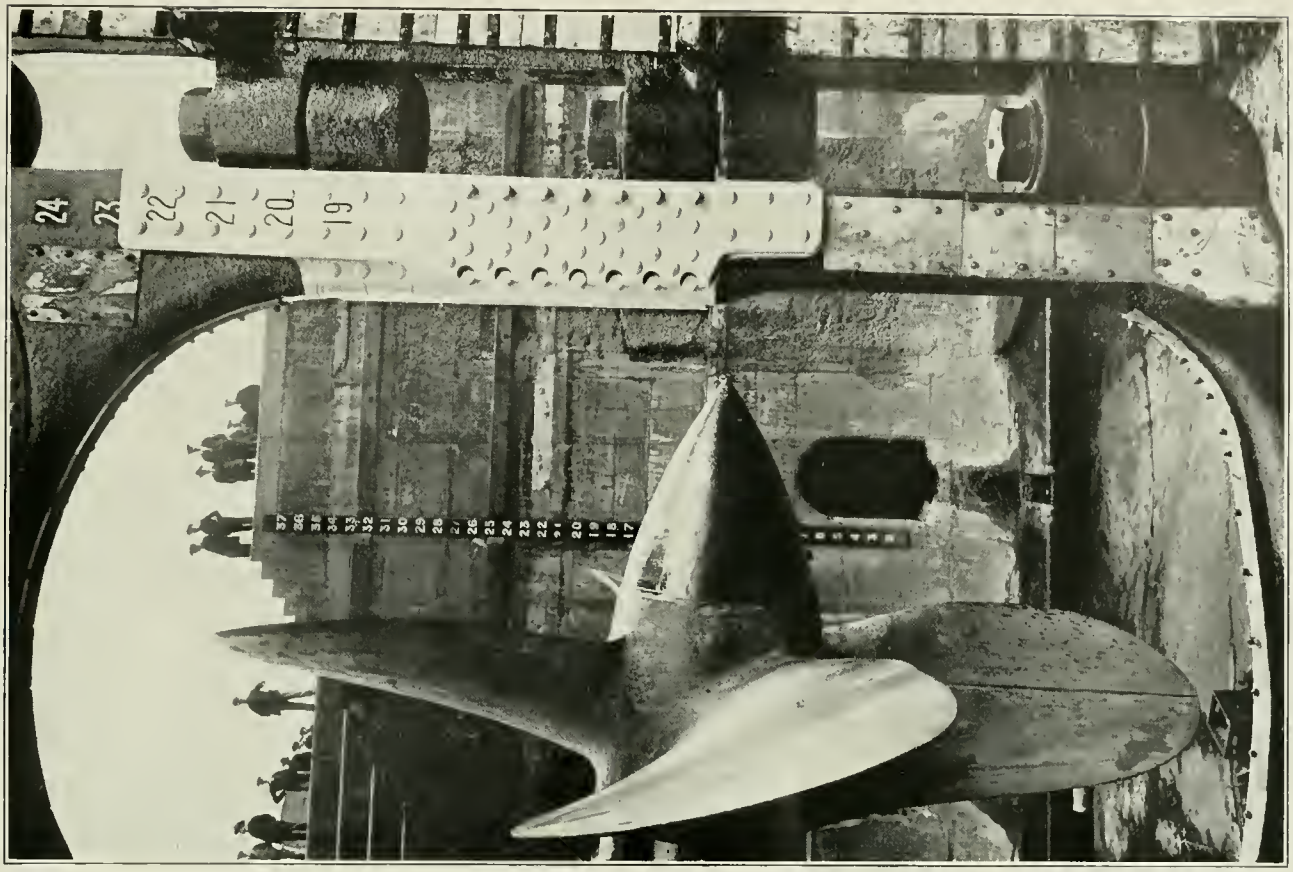
All the auxiliary machinery in the engine room, as well as the deck machinery, is electrically driven, the current being supplied by three dynamos, each of 60 kw. capacity, driven by Diesel engines designed and constructed by Burmeister & Wain. The pressure of the supply for power purposes is 220 volts, but for lighting purposes this is transformed down to 110 volts by means of a motor generator. Any one of the 60-kw. dynamos is sufficient to supply the necessary current required for normal working at sea, but two, or even all three, have to be in operation when the vessel is manœuvring in and out of harbour with the manœuvring compressor running, or when loading and discharging cargo. A small steam boiler of the cross-tube type, having about 100 sq. ft. of heating surface, is carried for supplying the steam to the heating installation in the accommodation.

The trial trip of the *Tennessee* was run on September 28, in the Sound at Copenhagen, when the following results were obtained :—

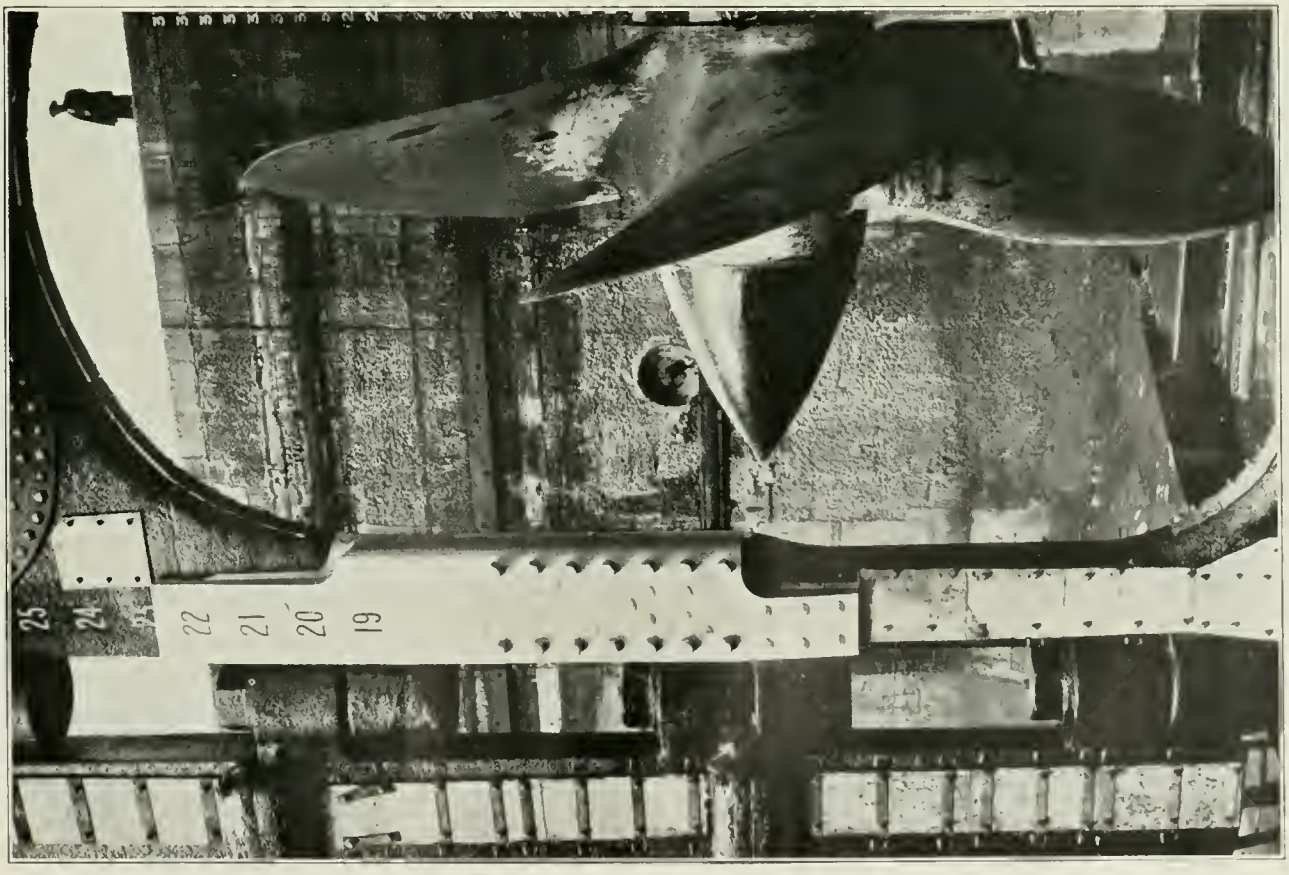
Mean draught on trial	9 ft. 8 in.
Displacement	4,415 tons.
Indicated horse-power, average	3,640.
Revolutions per minute, average	144.
Mean speed	12·6 knots.

During the consumption trial the main engines developed 3,434 i.h.p. at an average speed of 137·7 r.p.m. on a fuel consumption of 135·54 grammes (0·298 lb.) per indicated horse-power, the net calorific value of the fuel used being 10,152 calories per kilogram (18,274 B.Th.U. per pound). The fuel consumption given above includes the consumption of the auxiliary engines producing the necessary current for driving the auxiliary machinery, the steering gear and the electric light.

THE "OLYMPIC" STERN POST REPAIRS. (See page 417.)

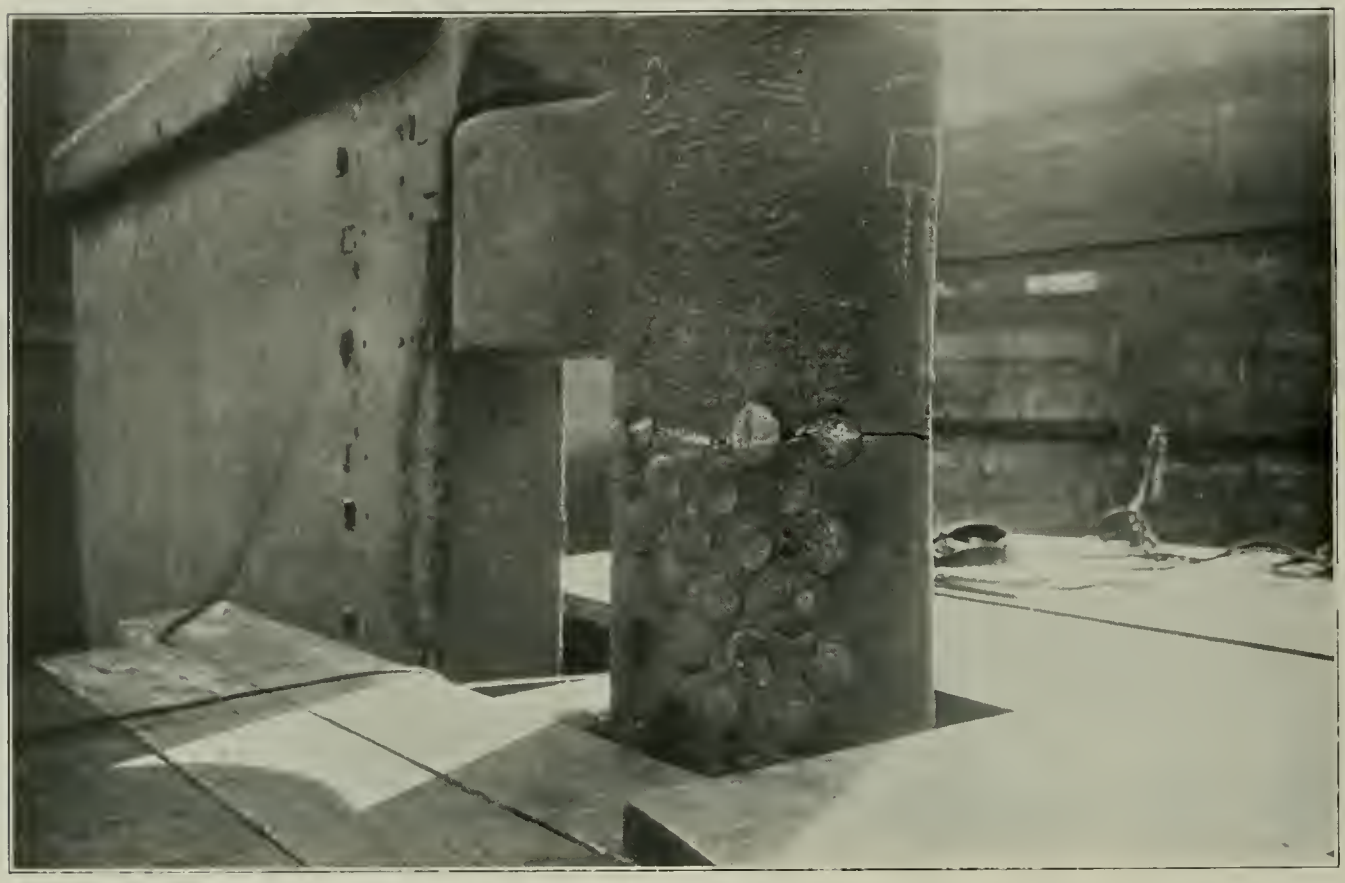


Port View of Patch, showing Slotted Holes for Countersunk Heads of Fitted Bolts.

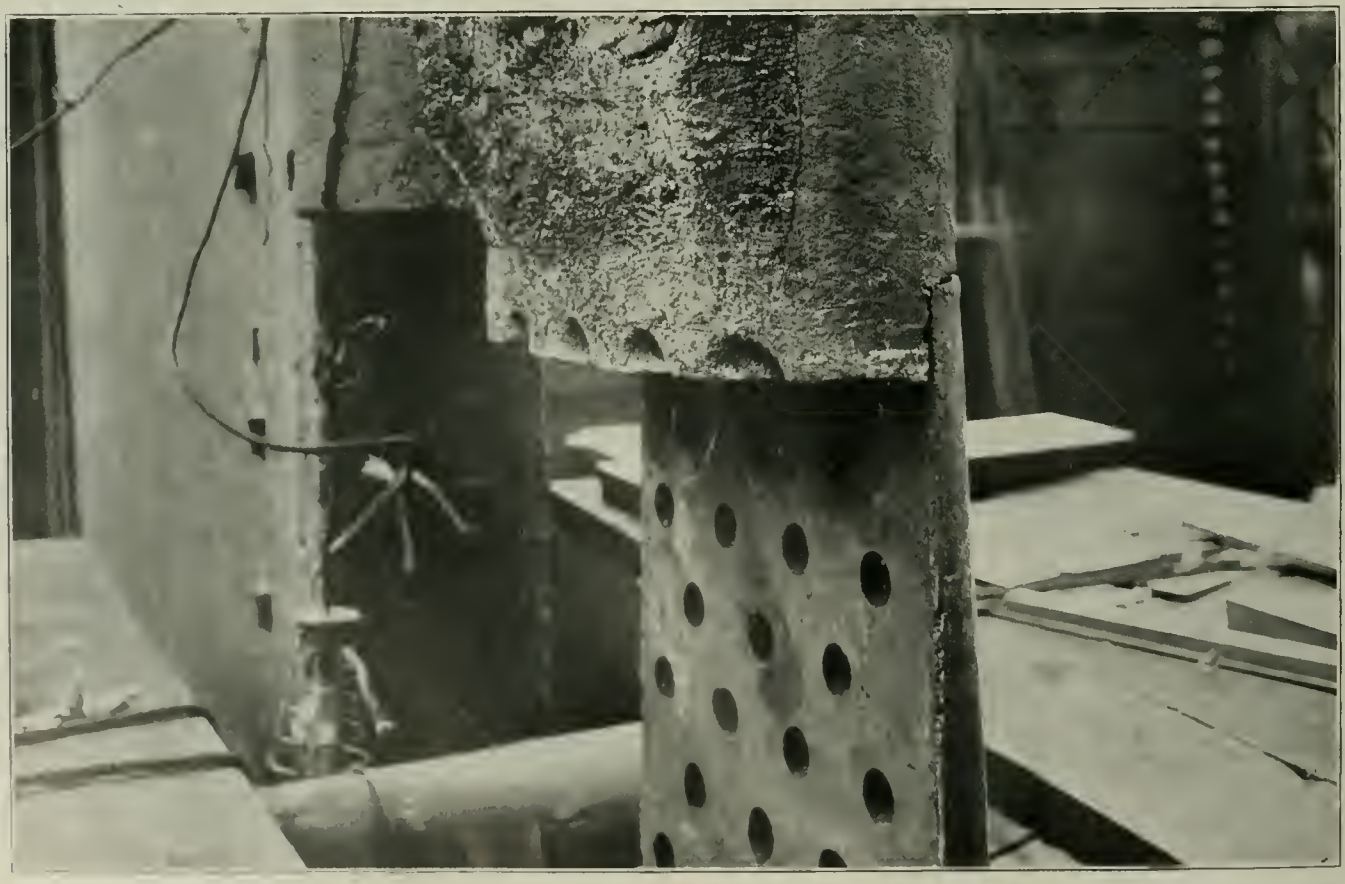


Starboard View of Repairs, showing Welded Sealing Strip at top right-hand corner of Patch.

THE "OLYMPIC" STERN POST REPAIRS.

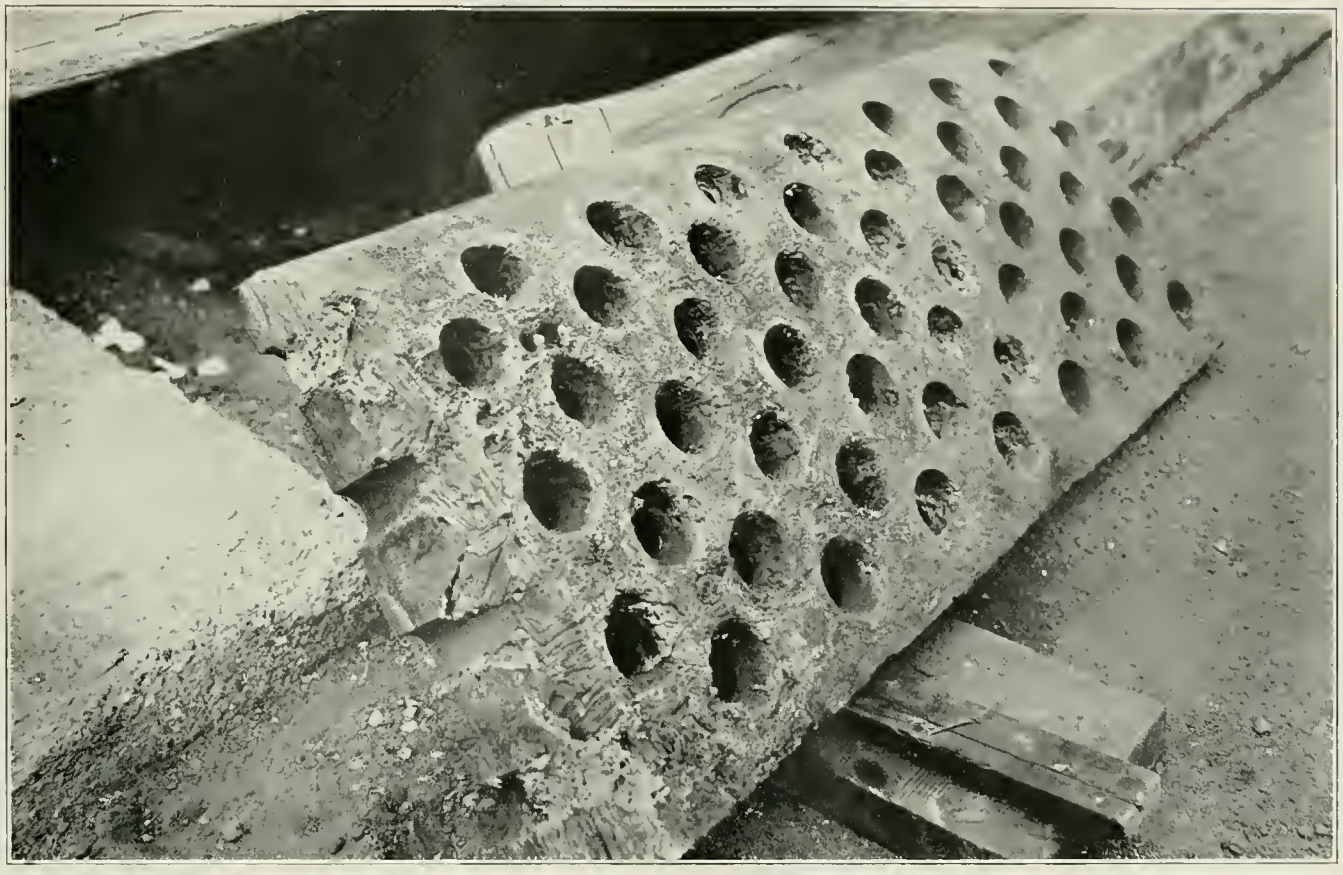


The Fracture, Prior to the Commencement of Repairs.

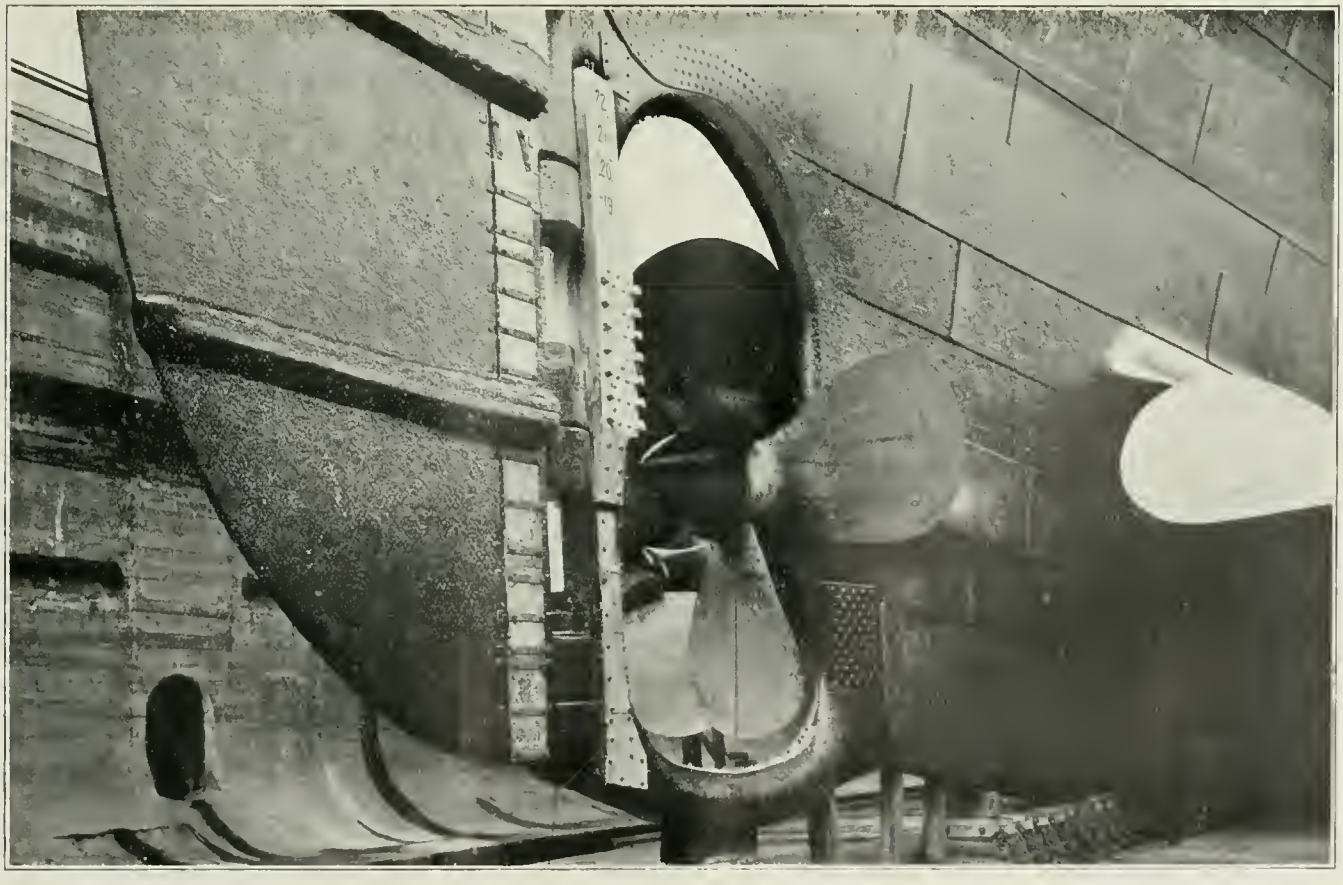


View from Starboard, showing Position of Fracture Relative to Scarph.

THE "OLYMPIC" STERN POST REPAIRS.

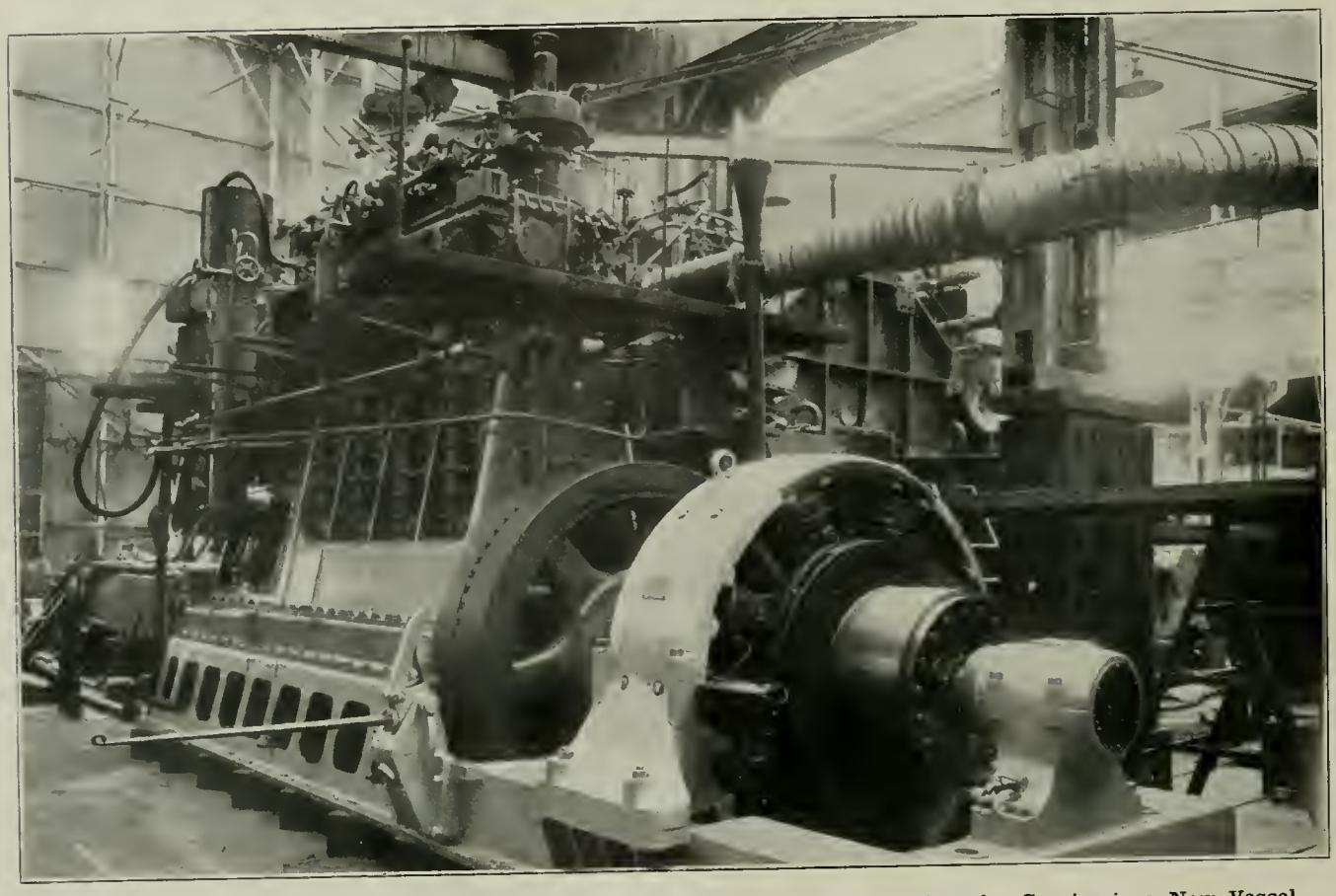


The Fractured Portion of Scarph Piece Dismantled.

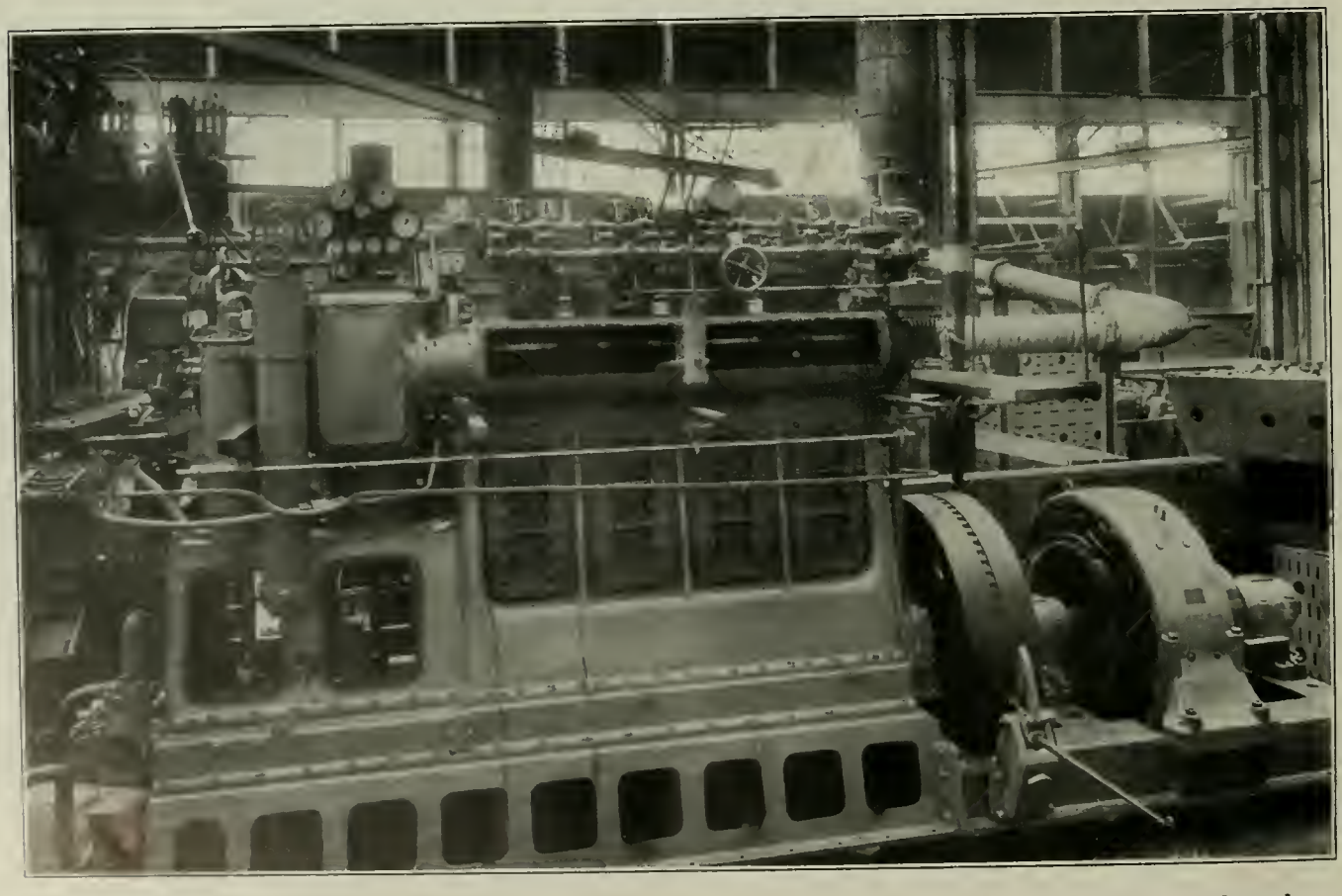


View from Dock Bottom, showing Repairs Completed. Note the substantial Nature of the Patch.

THE STEPHEN-SULZER TWO-CYCLE DIESEL ENGINE.



One of two 400 B.H.P. Stephen-Sulzer Two-Cycle Auxiliary Generating Engines for Service in a New Vessel building for the British India Steam Navigation Company, of London.



Another view of the 400 B.H.P. Four-Cylinder Engine on the Test Bed at the Works of the Builders, Alexander Stephen & Sons Ltd., Linthouse, Glasgow.

THE STEPHEN-SULZER TWO-CYCLE MARINE DIESEL ENGINE.

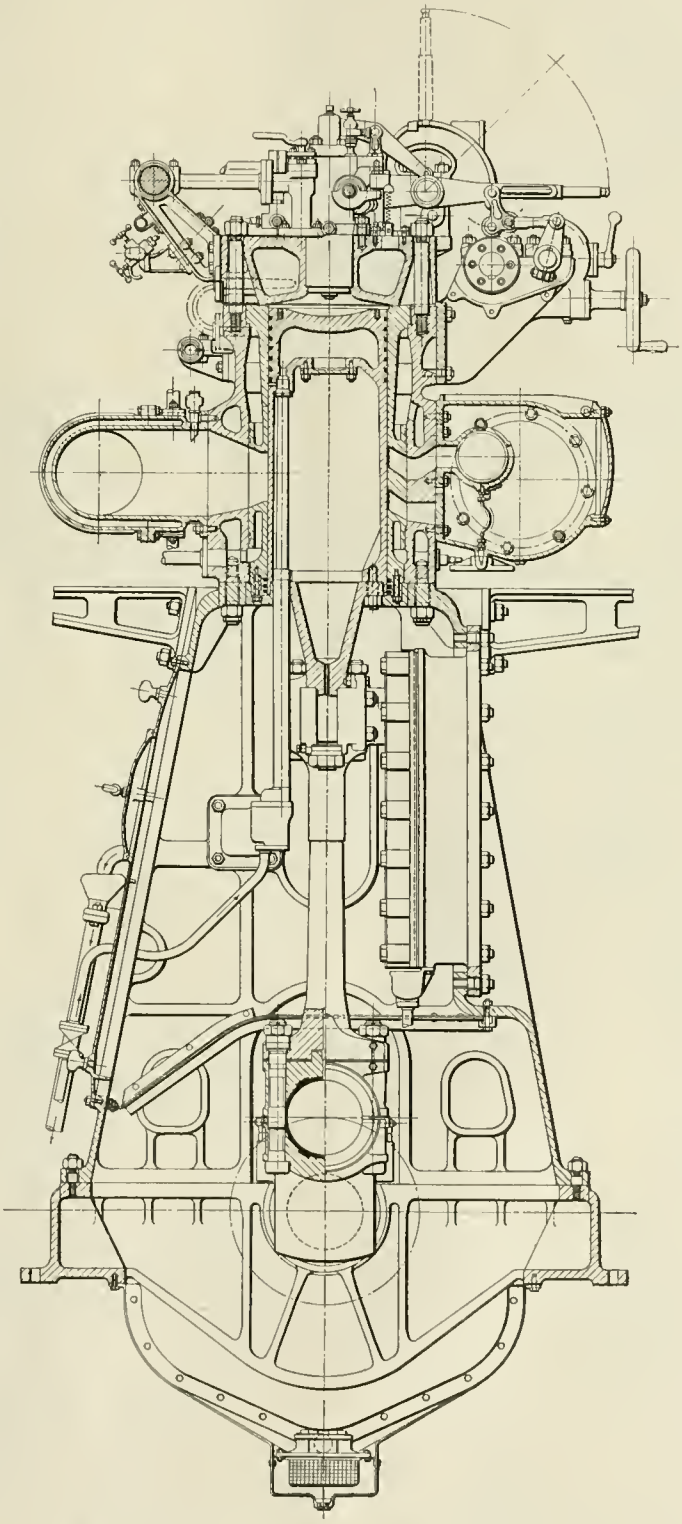
Two 400 B.H.P. Auxiliary Generating Engines—Constructional Features of the Stephen-Sulzer Engine—Particulars of Seven Days' Shop Trials.

We publish in this issue a series of drawings and photographs illustrating the Stephen-Sulzer marine Diesel engine, and interesting particulars of a seven days' trial on a 400 b.h.p. auxiliary engine are also given. This auxiliary engine, which has been constructed by Alexander Stephen & Sons Limited, of Linthouse, Govan, Glasgow, is one of two units built for driving the main generators in a new vessel for the British India Steam Navigation Company, of London. Each of these units was subjected to a seven days' continuous shop trial at various loads, and these trials, which we were privileged to attend, were productive of highly satisfactory results. We publish opposite two photographs illustrating the first of these units on the test bed at Stephen's Govan works.

The engine is of the 2-cycle single-acting type with 4 cylinders, each 340 mm. in diameter by 540 mm. stroke, and develops 400 b.h.p. at about 200 r.p.m. For testing purposes the engine was coupled to the direct-current generator, as shown, and the current produced was absorbed by a water resistance. The total weight of each engine, complete with scavenge pump, air compressor auxiliary pumps and all piping, is given as approximately 32·5 tons.

Special Features.

In the drawings which we publish on this and on the next page, the standard reversible marine engine is shown, but with the exception of a slightly modified valve gear and governor control, the design is in all respects similar to that for the non-reversible type, suitable for driving a ship's generating set. We shall now proceed to describe the more outstanding features of this auxiliary engine. As may be seen from the drawings the design, in general, embodies all the features which are met with to-day in high-class Diesel engine construction. Reference to the sectional end elevation on this page will convey a clear indication of the Sulzer method of port scavenging.



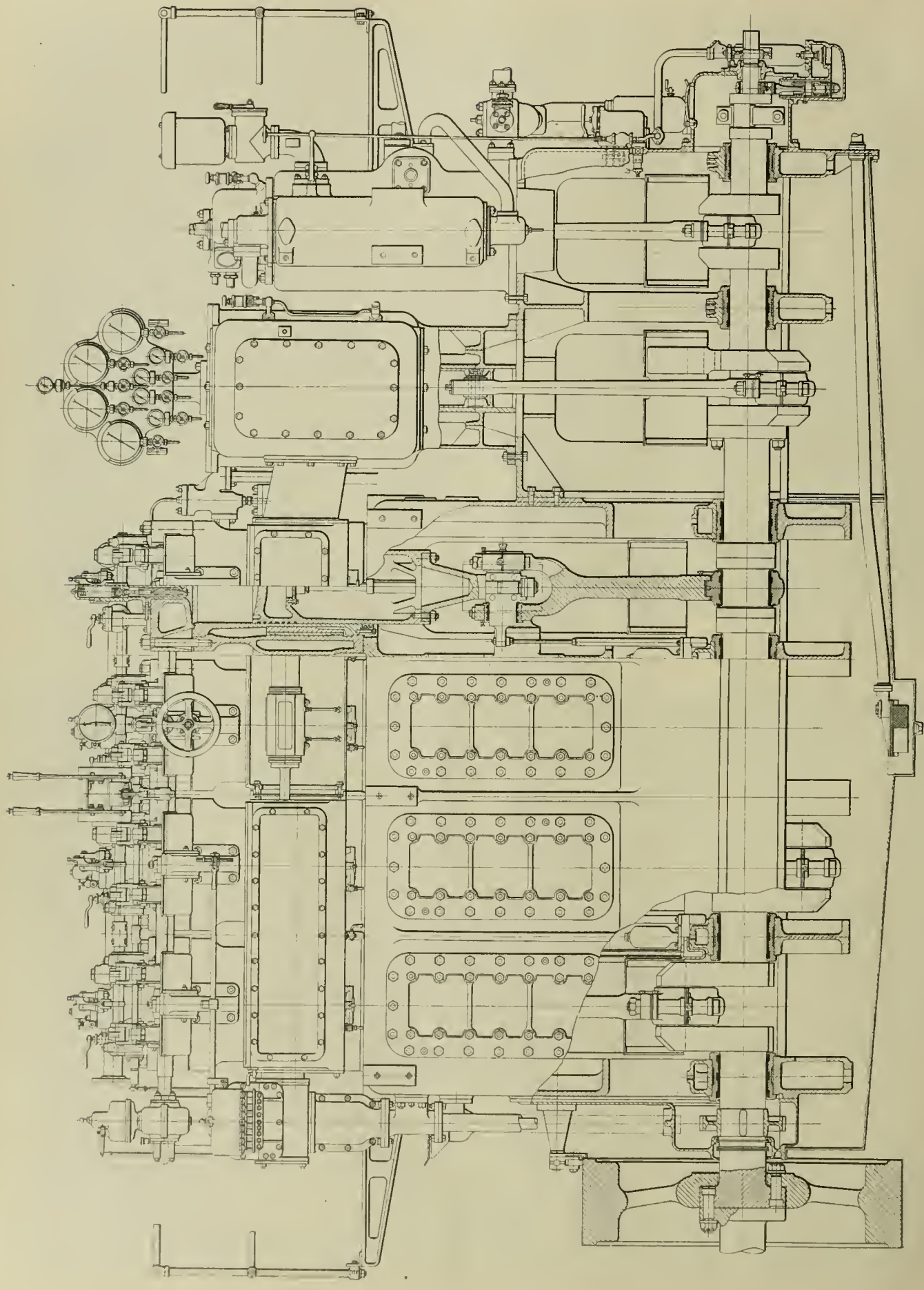
Sectional End Elevation of Sulzer Two-Cycle Diesel Engine.

The opening of the upper row of scavenge ports is controlled by a mechanically operated rotary valve situated in the scavenge main and driven from the vertical shaft by means of spiral gearing. In the case of the lower ports, opening is governed by the piston movement. During the downward stroke of the piston the upper ports are first uncovered, but, as the rotary valve at that instant is closed, no scavenging air is admitted to the cylinder. The exhaust ports are now uncovered and the products of combustion are free to escape to the atmosphere. At this point the piston next uncovers the lower scavenge ports, and scavenge air, at a pressure of about 2 to 3 lb. per square inch, is now admitted to the cylinder, thus expelling the exhaust gases which still remain and the pressure of which has now fallen to approximately that of the atmosphere.

Supercharging.

The rotary valve, already referred to, commences to open slightly before the lower ports are uncovered and a combined scavenging effect from the upper and lower ports is obtained. By this means a large volume of air is provided over a given period. During the upward stroke of the piston, and at the point of closing of the exhaust ports, the upper scavenge ports still remain open, and until these are again covered by the piston, scavenge air continues to flow into the cylinder, thus effectively filling the cylinder with pure air, which is impressed for the subsequent impulse stroke. An advantage claimed for this method is that a certain degree of supercharging is effected which has its reflex in a higher efficiency of the complete cycle.

In the construction of this engine it will be observed that, although it is a unit of comparatively low power, crosshead guides have been adopted. This feature is one which is likely to find favour with marine engineers, since the troubles which are frequently associated



Longitudinal Elevation and Part Section of Sulzer Four-Cylinder Two-Cycle Marine Diesel Engine.

with the employment of trunk pistons are entirely eliminated and the cylinder liner is relieved of all thrust pressures arising from the obliquity of the connecting rod.

Cooling Arrangements.

Piston cooling is effected by means of fresh water in view of the nature of the waters in which the vessel will be called upon to operate, but as an emergency measure, provision has also been made so that sea water may be utilised for cooling the piston heads should the exigencies demand. Sea water circulation is employed for the cylinder jackets, covers and exhaust-main jacket. A special feature of this engine, as of all Sulzer engines, has reference to the simplicity of the cylinder cover design. This design will appeal to many whose experience has not been unmarked by troubles, and, in some cases, failures arising from cylinder cover weaknesses. The casting is perfectly symmetrical and is provided with but one central opening in communication with the combustion space. This opening accommodates the combined casting containing the fuel and starting air valves. With regard to starting and control, the engine is divided into two groups of two cylinders each, and starting air is initially admitted to all four cylinders. Subsequently two cylinders are put on fuel with the remaining two still running on air, and finally all four cylinders are put on fuel. As the duty of this engine consists of driving a direct-current generator, the governing under varying loads is entirely automatic, the speed fluctuation between no load and full load being 8 per cent. momentary and 5 per cent. permanent. This is accomplished by means of a centrifugal type governor, acting through levers and rods on the following parts :—

(*a*) The suction valves of the fuel pumps.

(*b*) The low-pressure suction throttle valve of the air compressor.

Should the load vary, due to the demands on the ship's auxiliaries, the governor immediately takes control, in the first place by adjusting the amount of fuel delivered by the fuel pumps, and in the second place by regulating the first stage air compressor delivery pressure, from which a connection is led to a servo-motor operating the fuel injection control levers. Accordingly, as this air pressure is increased the period of fuel injection is also regulated to suit the particular load conditions. A hand control gear is also provided for regulating the fuel injection when required, as, for example, when starting up the engine. The scavenge air is supplied by a double-acting scavenge pump driven from the forward end of the crank shaft, and this pump maintains an air pressure of from 2 to 3 lb. per square inch under normal full load conditions. As the drawings will show, a three-stage tandem air compressor for the injection air supply is driven from the crankshaft direct. Other engine-driven pumps include a jacket cooling pump, one water service pump, one piston cooling pump and one forced lubrication pump.

Above we show in tabular form the results from 168 hours' continuous run with the port generator engine at varying loads. The fuel used on test had a specific gravity of

(*Continued on page* 436.)

—	½ Load.	¾ Load.	9/10 Load.	—	Lubricating oil consumptions.		Cooler water consumption.
					Bearing oil.	Cylinder and compressor oil.	
Collective indicated horse-power ..	314	381	457	—			
Generator output ... .. . kw.	135	200·3	237·5	—	Gallons per hour = 0.369.	Gallons per hour = 0·0866.	Jackets, &c.
Equivalent b.h.p. (allowing for generator efficiency)	204·1	295	354	—	Pounds per b.h.p. hour = 0·0139.	Pounds per b.h.p. hour = 0·0032.	Gallons per b.h.p. hour = 14
Engine mechanical efficiency .... per cent.	65	77·5	77·5	—			
Revolutions per minute	201·4	200·3	200				
Mean indicated pressure .... lb. per sq. in.	51·3	63·4	75·5	Pressures — lb. per sq. in.			
Injection air pressure . ,, ,,	752	850	950		"Clyde" extra heavy rotarine turbine oil.	"Clyde" solverine oil "A."	Piston cooling and fuel valve casing.
Scavenge air pressure .... ,, ,,	2·5	2·7	2·8				
Forced lubricating— Main bearings .... . ,, ,,	15·2	18·2	16·6		F.P. = 410° F. (close).	F.P. = 490° F. (close).	Gallons per b.h.p. hour = 2·31.
Crosshead pins ... . ,, ,,	53·8	57	52·5		Burning point = 498-500° F.	Viscosity— 20·3 (Engler) at 120° F.	
Jacket cooling . . ,, ,,	4	4	4				
Piston cooling ... .. . ,, ,,	23·6	28	29·6				
Forced lubricating temperature .... inlet	90° F.	95° F.	105° F.	Temp. F.			
Piston cooling temperature .... outlet	96° F.	102° F.	110° F.				
Fuel oil consumption— Pounds per hour	98·0	140·0	160·0		Fuel oil used—Diesel oil—Sp.G. = 0·895. F.P. = 160°-170° F.		
Pounds per indicated horse-power hour ...	0·312	0·367	0·35		Sulphur content = 0·8 per cent.—Cal. value 19,300 B.Th.U./lb.		
Pounds per brake horse-power hour . . .	0·482	0·474	0·452		Viscosity—at 70° F. = 235 secs.		

Data taken during Seven Days' Shop Trials of the 400 B.H.P. Stephen-Sulzer Diesel Engine.

LETTERS TO THE EDITOR.

DUMB BARGE RUDDER DESIGN.

To the Editor of
The Marine Engineer and Naval Architect.

I have noted with interest the criticism of your correspondent "Gouvernail" in the October publication on my article "Dumb Barge Rudder Design."

It is universally agreed that, for the type of craft under discussion, the approximately rectangular rudder is most suitable and efficient. If your correspondent again refers to page 350 he will see that the general shape which the rudder should assume was not discussed; the only point which I raised in this connection was whether any rudder area should be placed in way of the keel line produced, or not.

I also note that he objects to the use of Colonel Beaufoy's formula for the estimation of water pressure acting on the rudder, but I would point out that as its application errs on the side of safety, and in view of the severe and erratic service to which such craft are subjected, it can be well recommended. The congested traffic on our estuaries and leading waterways necessarily involves unusual quickness of manœuvring at comparatively high speeds of towing, and further, where hired tugs are employed to effect towage, the speed may vary from 5 to 10 m.p.h. This alone necessitates the adoption of a high factor of safety in the component parts of the rudder, and any additional strength introduced by the adoption of Beaufoy's formula would prove beneficial.

Those acquainted with our leading estuaries and associated canals will at once recognise the necessity of designing the craft which navigate them to satisfy the more severe conditions on the estuaries, and it is for this reason that the average block coefficient does not usually exceed 0·800. This degree of fullness ensures ease of handling by manual power and provides economical craft for towing. On page 352 I mentioned a wake allowance of 6 per cent., but I note your correspondent has wrongly assumed this to apply to the conditions prevailing on the canals and not to those on the estuaries. The two services have very little in common and the direct method of comparison adopted by my critic is therefore of no practical value. I would also point out that the "Venturi" theory referred to applies more particularly to the water between the sides of the barge and the canal banks rather than to the limited water which invariably exists between the barge bottom and canal bed. Where the bottom clearance is small, bottom drag would unavoidably take place, and would render any rudder area placed in the vicinity of the keel line produced, of little manœuvring value. The actual results, however, depend on the condition, dimensions and formation of the canal section.

Having in mind the comparatively high speed of towage, it is essential that the rudder arms be designed to give the necessary stiffness to withstand the high bending strains induced and not left merely to chance as suggested by your contributor.

In conclusion, I may add that my critic has, apparently, overlooked the fact that the article which he criticises refers to craft which are required to navigate both estuaries and canals and *not* to the abormally full type of barge usually found on the inland Continental canals, where the service is neither severe nor erratic.

"WATERWAY."

DEVELOPMENTS IN NON-FERROUS WELDING.

Considerable progress has been made during the last few years in the various processes of welding, and it is now well known that not only in new construction, but also in repairs, the use of the electric arc is attended by many advantages. The latest development to be brought to our notice has reference to the welding and depositing of non-ferrous metals, such as copper, bronze and brass, and three new electrodes have been brought out by the Alloy Welding Processes Limited, of 14-16, Church Street, London, N.1. These new electrodes, in the first place the result of exhaustive research work at the company's laboratories, have now been sufficiently developed to be available on a commercial scale. In composition the new electrodes comprise a pure copper core, surrounded by a flux covering which has strong adhesive properties and does not break away from the core during the rough usage in transport. This flux covering is of special composition, being graded in accordance with the nature of the alloy to be welded, and produces a powerful reducing atmosphere around the work, thus ensuring the deposition of a good metal. As is generally known, copper and its associated alloys have a very short temperature range between the welding and the fusing points, and the exercise of judgment is necessary on the part of the operator to ensure that the metal shall neither be too fluid nor yet too sluggish. With its high heat conductivity the deposited copper will impart its heat to the main body of the alloy, so that, for successful amalgamation, preheating is necessary. In the case of the "A.W.P." electrodes local heating along the line of the weld will generally be found to be sufficient, and this heat may be conveniently applied by a blow lamp. It is stated that the metal deposited with these electrodes is perfectly homogeneous and free from blow-holes.

ENGAGEMENTS FOR NOVEMBER.

Institute of Marine Engineers.—Annual Dinner in Grand Hall, Hotel Cecil, Strand, London, W.C., on Friday, November 3, at 6.15 for 6.30 p.m. Reception by the President, Engineer Vice-Admiral Sir George G. Goodwin, K.C.B., LL.D.—Meetings at the Institute, the Minories, Tower Hill, London, E., at 6.30 p.m.: Tuesday, November 14, "Evolution of the Nobel Diesel Engine," by G. J. Steinheil, B.Sc. (Member).—Tuesday, November 28, Film illustrative of the "Conquest of Oil:" Anglo-American Oil Company. Ladies invited.

North-East Coast Institution of Engineers and Shipbuilders.—Meeting in Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne, on Friday, November 3, at 7.30 p.m. "Working Practice in the Design of Large Double-Acting Two-Stroke Engines," by Alan E. L. Chorlton. Friday, November 17, "Notes on Torsional Oscillations, with Special Reference to Marine Reduction Gearing," by A. T. Thorne, B.Sc. (Associate Member), and J. C. Calderwood, M.Sc. (Graduate).

Institute of Metals.—*London Local Section.*—Meeting at the Royal School of Mines, South Kensington, S.W., at 8 p.m., Thursday, November 9, "The Production of Large Crystals of Aluminium and Some of their Properties," by Prof. H. C. H. Carpenter, F.R.S.

Belfast Association of Engineers.—Meeting in Municipal College of Technology, on Thursday, November 16, at 7.30 p.m., "Historical Progress of Reversing Rudders," by D. M. Denholme, A.M.I.N.A.

Institution of Engineers and Shipbuilders in Scotland.—Meeting in the Rankine Hall, 39, Elmbank Crescent, Glasgow, on Tuesday, November 21, at 7.30 p.m. Papers and discussion.

Institution of Mechanical Engineers.—Extra general meeting at the Institution, Storey's Gate, St. James's Park, Westminster, S.W., on Friday, November 24, at 6 p.m. Adjourned discussion on "Air Compressors," by William Reavell (Member of Council).

THE NEW ANCHOR LINER "TUSCANIA."

Twin-Screw Passenger and Cargo Liner, of 17,200 Gross Tons, Built and Engined by the Fairfield Shipbuilding & Engineering Company, Limited, Govan, Glasgow, to the order of the Anchor Line (Henderson Bros. Limited), Glasgow. Fitted with Brown-Curtis Tubines of 13,500 s.h.p. driving through Double-Reduction Gears.

The Fairfield Shipbuilding and Engineering Company have just completed, to the order of the Anchor Line (Henderson Brothers Limited), Glasgow, the twin-screw geared-turbine steamer *Tuscania* for the North Atlantic cargo and passenger trade. The vessel is of the following dimensions :—

Length, overall	578 ft. 6 in.
Length, between perpendiculars	550 ft.
Breadth, moulded	70 ft.
Depth to bridge deck	51 ft. 3 in.
Load, draught	28 ft. 11¾ in.
Tonnage	17,200 tons gross.
Deadweight, about	10,700 tons.

The vessel, which has been built under special survey to the rules of the British Corporation, is subdivided by 10 watertight bulkheads into 11 main transverse watertight compartments. The fore peak bulkhead is carried up to the bridge deck, and the others extend to the shelter deck. The *Tuscania* is of the shelter deck type of vessel and has a straight stem and cruiser stern. She is fore and aft rigged with two masts and only one funnel. Accommodation is provided for 104 first-class passengers, 163 first-, interchangeable to second-class, 377 second-class and 1,818 third-class passengers, while provision is made for a crew of 342.

The general arrangement of the propelling machinery, as shown by the drawings on page 429, gives some indication of the size and number of units of machinery in a modern geared-turbine vessel, with its multitude of pipe systems and recording fitments. The machinery is placed in two watertight compartments, no auxiliaries being situated in the tunnel. The main turbines and gearing are designed for a maximum total shaft horse-power of 13,500 at about 93 r.p.m. of the propellers, the normal sea power being 12,500. The twin propellers are four-bladed and 20 ft. in diam. There are altogether six ahead turbines and four astern incorporated turbines in the ship, each set of three ahead working in series and driving two first reduction pinions. The second reduction pinions are mounted on the same spindles as the first reduction wheels and drive the main gear wheel. Three double-ended and three single-ended cylindrical return-tube boilers constitute the steam-generating plant and these boilers are arranged to burn oil, but provision has also been made for readily converting to coal burning. The boilers, as will be seen from the drawings on page 432, are placed three abreast and fitted with Howden's system of forced draught. Fans draw the air from the firing spaces through large trunks, keeping the stokehold cool and at the same time supplying heated air to the furnaces. All uptakes from the boilers are led to one large funnel, an arrangement which has several distinct advantages from the point of view of the passenger accommodation.

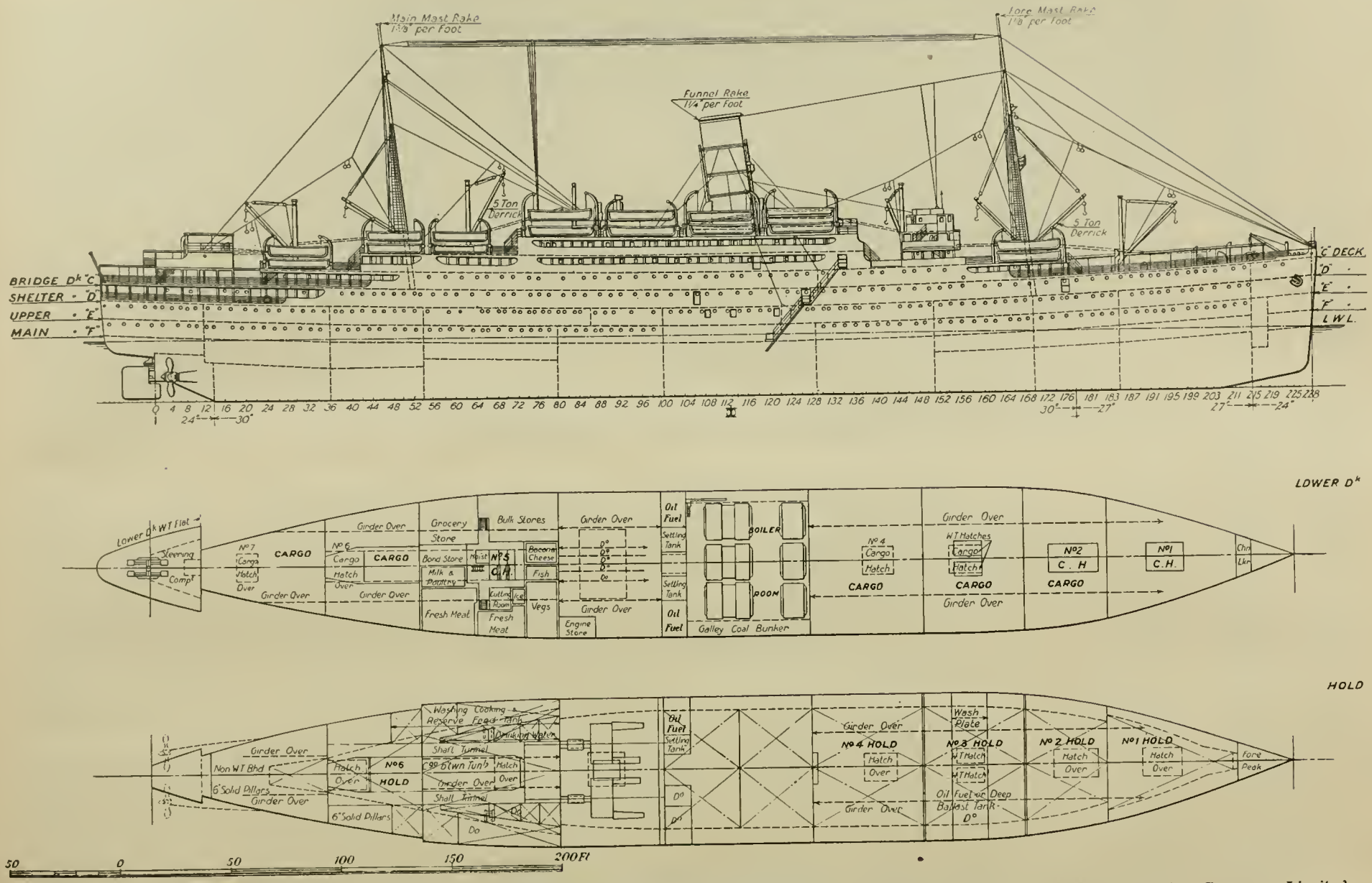
Main Propelling Machinery.

The main propelling machinery consists of two sets of turbines of the Brown-Curtis type driving twin screws through double-reduction gearing. The ahead portion of each set comprises three separate turbines in series, the H.P. and M.P. being coupled in tandem driving one pinion on the inboard side of each gear, and the L.P. turbine driving the outboard pinion. The designed revolutions of the inboard turbines are 2,840, and the outboard 1,830 per minute. Astern turbines, capable of developing about 70 per cent. of the full ahead power, are placed in the M.P. and L.P. casings. The design of the rotors is such that an ample margin of safety is ensured as regards the critical speed of rotation. There are three stages in the H.P. turbine, of the velocity compounded type, each having two rows of moving blades. The M.P. turbine has one 2-row stage and seven single rows, while the L.P. has 11 single rows. The astern turbines are made up of one 3-row stage for the H.P. and one 3-row and one 2-row stages for the L.P. All blading is of phosphor bronze, suitable for superheated steam, and is milled from the solid bar, making a combined blade and packing piece. The H.P. casing is of cast-steel while the other casings are of cast-iron of strong construction, designed to resist distortion due to temperature changes, and also, in the case of the L.P. turbine, to the weight of the suspended condenser. The nozzle plates at the inlets to the H.P. ahead and H.P. astern turbines and the diaphragms between the stages in the H.P. ahead are of phosphor bronze, with nickel steel blades embedded in the castings. The other nozzle plates and diaphragms not subjected to superheated steam are of cast-iron. Ready access to the rotors, packings and blades for inspection or overhaul has been ensured by making all the diaphragms of the split type and so arranged that their upper halves are retained within the turbine covers when the last named are lifted. The rotors are built up of forged-steel discs forced on and keyed to forged-steel spindles, and steam-packed glands of the carbon ring type are fitted to each turbine. The inter-stage diaphragms are packed with serrated rings of phosphor bronze. The turbine adjusting blocks are of the Michell type with double-sided collar for ahead and astern running respectively.

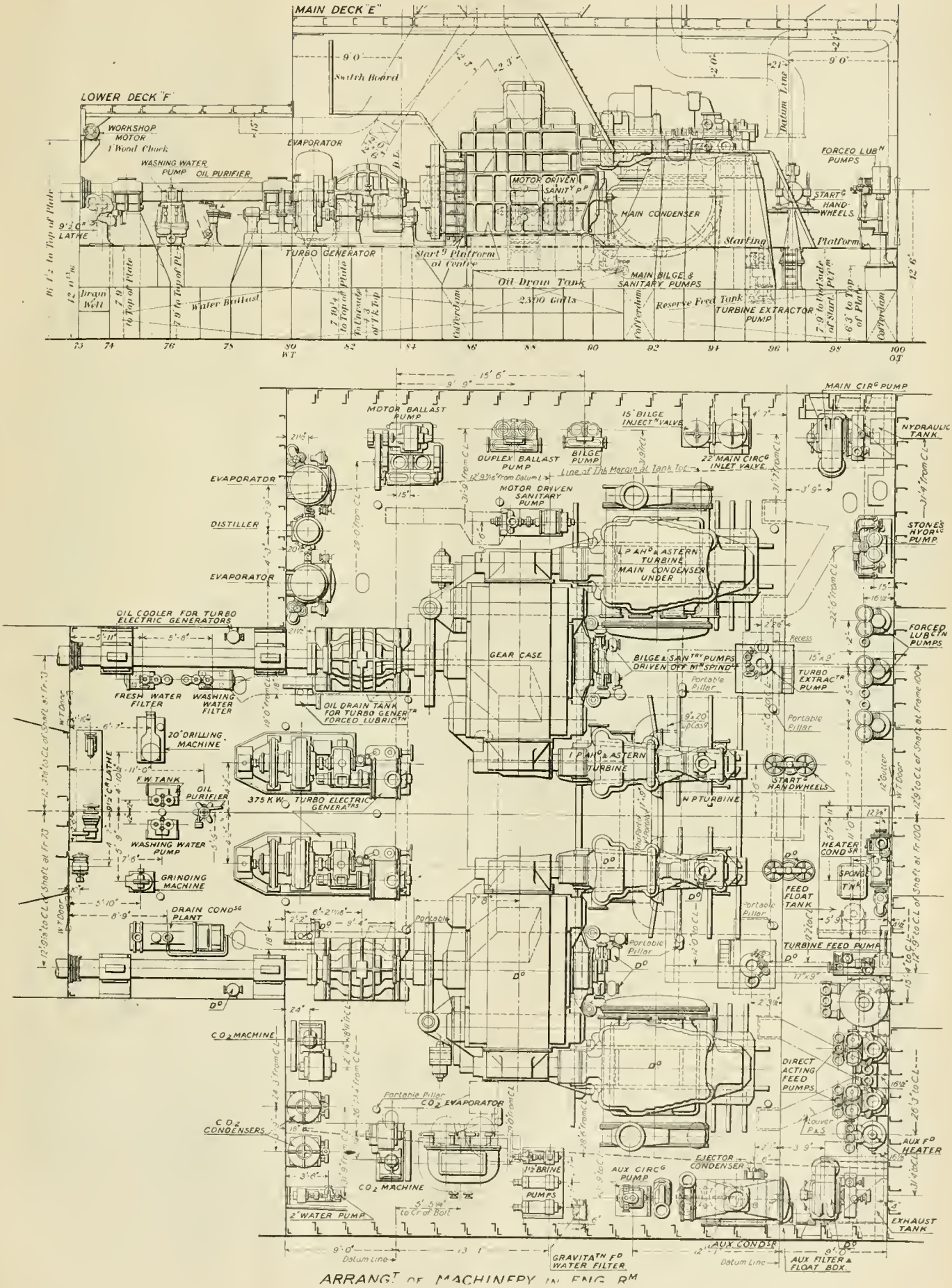
To prevent overspeeding, an Aspinall governor of the latest pattern is fitted at the forward end of each turbine. An emergency hand cut-out gear is also fitted, and since the governors work through an oil pressure relay from the main lubricating system, they also come into action in the event of a reduction in the pressure of the oil supply to the bearings or sprayers of a predetermined amount. Both main condensers are placed athwartships, one being suspended immediately beneath each L.P. turbine. These condensers are of the two-flow type, of ample surface for the service conditions, and are built up of steel plates, cast-iron doors and waterways and brass tubes and tube plates. One circulating pump with 22 in. diam. discharge driven by an impulse turbine is provided for each condenser. To reduce erosion of the tubes, both in the condenser and in the boilers, the Cumberland electrolytic system has been fitted.

Reduction Gearing.

The double-reduction gearing is of massive construction, embodying the usual arrangement whereby the first reduction wheels are contained in the central gap between the two helices of the main wheel. The gear teeth are of the Parsons standard form, of the same pitch for both steps of the reduction, the materials employed being nickel steel for the pinion teeth and forged steel for those on the wheels. The centres of the wheels are of cast-iron with the rims shrunk on. All the bearings, together with the turbine bearings, are lubricated under pressure, while the gears themselves are sprayed with a continuous supply of specially cooled oil. The bottom of each gear case forms a sump from which the spent oil is drained to a tank formed in the structure of the double bottom whence

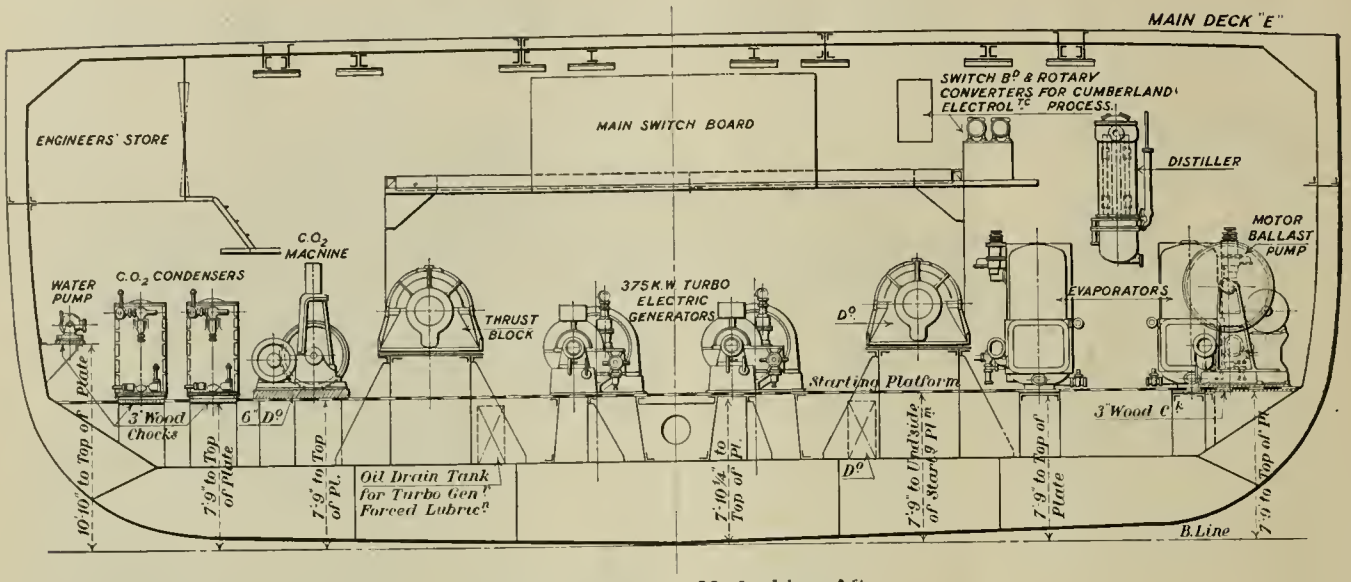


Twin-Screw Passenger and Cargo Liner "Tuscania," of 17,200 Gross Tons, Built and Engined by the Fairfield Shipbuilding & Engineering Company Limited, Govan, Glaegow, for the Anchor Line (Henderson Brothers Limited), Glasgow.

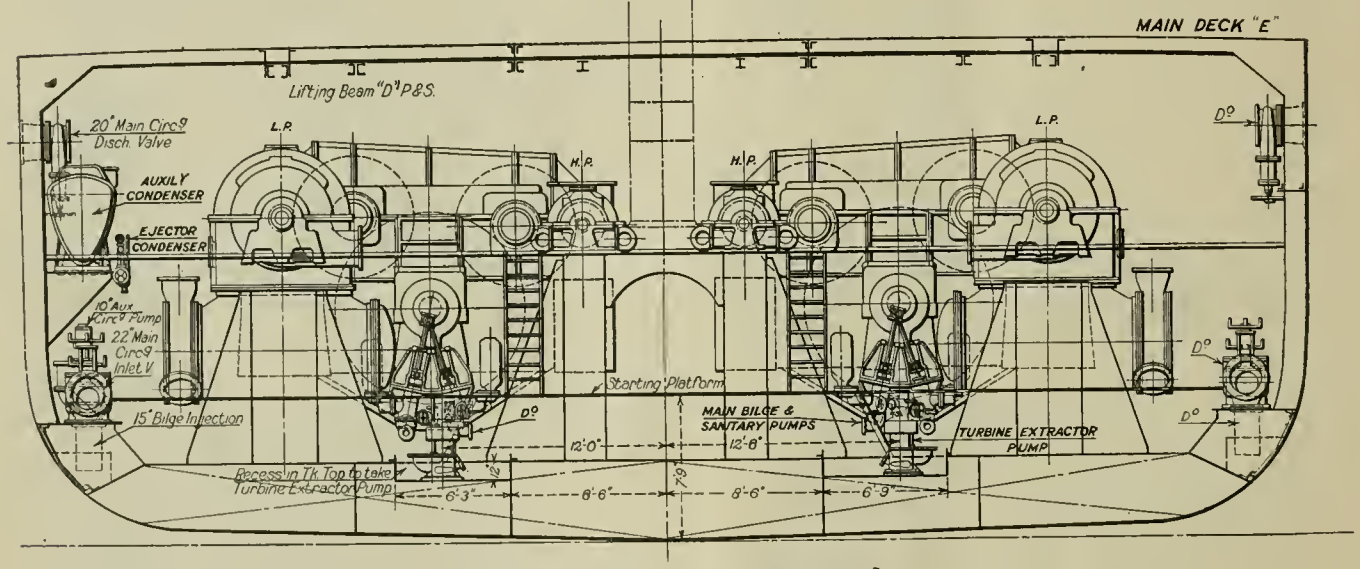


General Arrangement of Main and Auxiliary Machinery, in Elevation and Plan, on the "Tuscania."

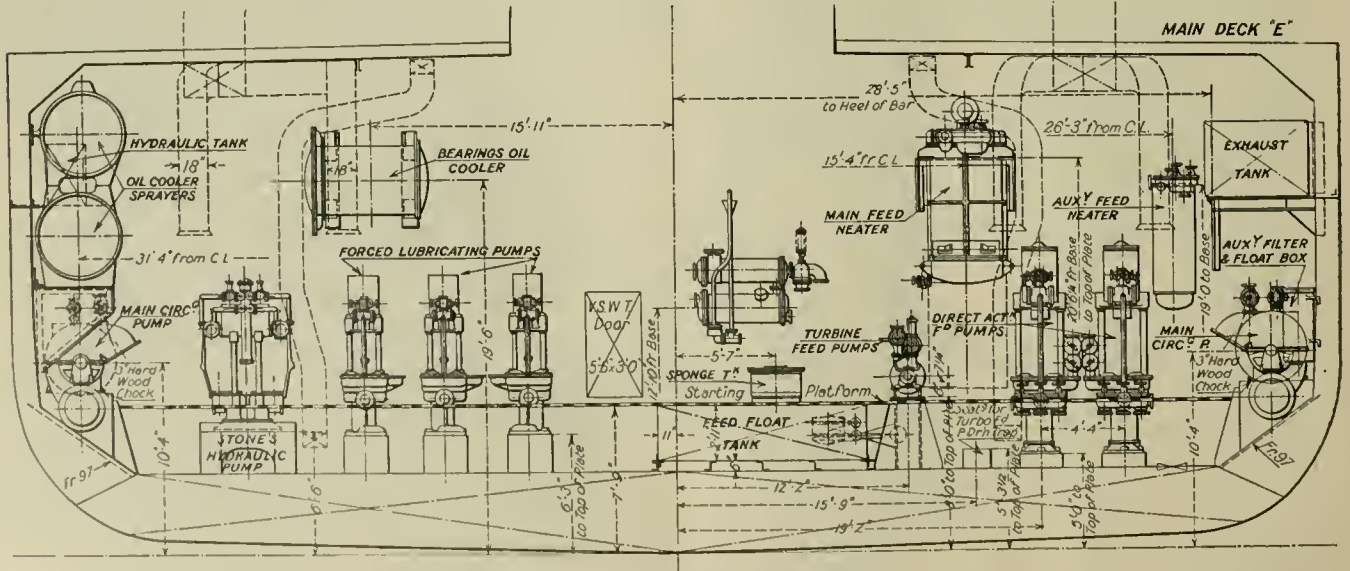
THE NEW ANCHOR LINER "TUSCANIA."



Section at Frame 86, looking Aft.



Section at Frame 96, looking Aft.]



Section at Frame 96, looking Forward.

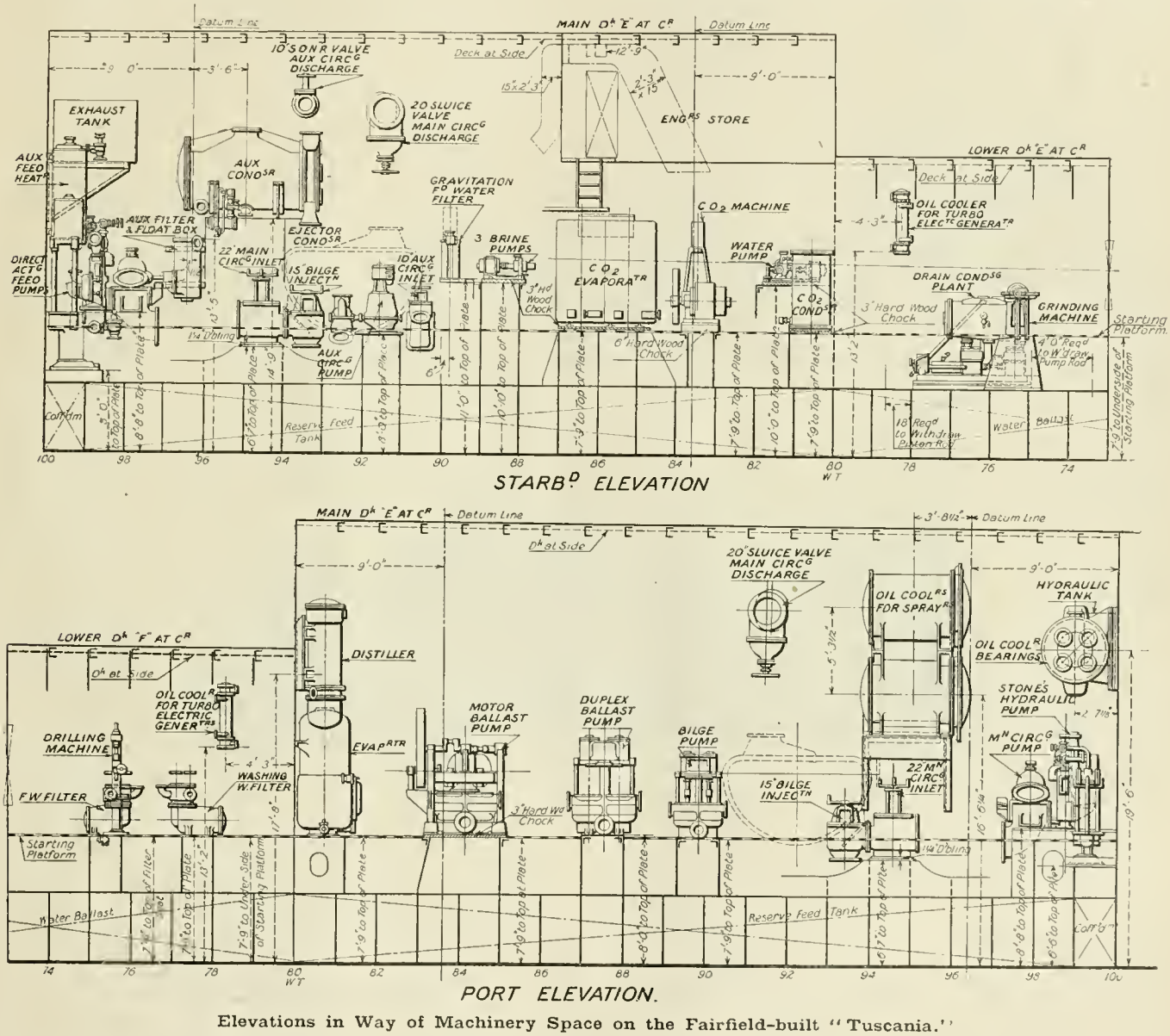
it is pumped through the filters and coolers, returning finally to the forced lubrication supply mains. Bilge and sanitary pumps are driven by a crank from the forward end of each main gear-wheel spindle. For turning the shafting, a large worm wheel is mounted on the aft coupling of the gear wheel, power being supplied through a train of wheels by an electric motor. Lifting blocks and tackle have been arranged so that the turbines and gearing can be overhauled and examined with the minimum of labour.

All six boilers are of 17 ft. 6 in. mean diam, the double-ended being 22 ft. 6 in. and the single-ended 11 ft. 6 in. in length. The working pressure is 220 lb. per sq. in. and the steam is required to be superheated 200° Fahr. at the turbines. The "North Eastern" type of superheater, installed by the North Eastern Marine Engineering Company, Wallsend, is fitted to all boilers. Each boiler end is fitted with four Morison furnaces 44¼ in. internal diameter, *i.e.*, 36 in all. The furnaces, as already explained, are arranged for oil burning but can be readily converted to coal. Under oil-burning conditions the total heating surface is about 32,500 sq. ft., and when fitted for coal 746 sq. ft. of grate area is available. Air is drawn from the firing spaces and supplied to the furnaces by four forced draught fans 75 in. diam., driven by two motors placed at the aft end of the boiler room. The usual Howden air heating tube boxes are arranged in the uptakes at the boiler fronts.

The oil fuel is burned on the Wallsend-Howden system, and for this purpose there are installed at the aft end of the boiler room four independent sets of pumps, heaters and strainers. Two of these sets are each capable of supplying the double-ended boilers, and each of the other two sets of smaller size, the single-ended boilers. An auxiliary heater and a motor-driven pump are also installed for lighting-up purposes. Between the engine and boiler rooms are situated the fuel oil settling and storage tanks, having a total capacity of about 350 tons. The main supply of the bunker oil is carried in the double-bottom tanks, while a reserve store can be carried in one of the deep tanks if necessary. For transferring oil from the bunker tanks to the settling tanks two Weir's pumps are fitted. These pumps have also a connection to the oil bilge. A "W. R." CO_2 recorder is fitted in the stokehold with a connection to each of the nine uptakes so that the engineer may ascertain the nature of the combustion taking place at any time. Stokehold ventilation is very efficiently accomplished by four large vent trunks which extend down to the centre line of the boilers. Screens are so arranged that the warm air finding its way to the fan suction trunks creates a continuous current throughout the firing spaces.

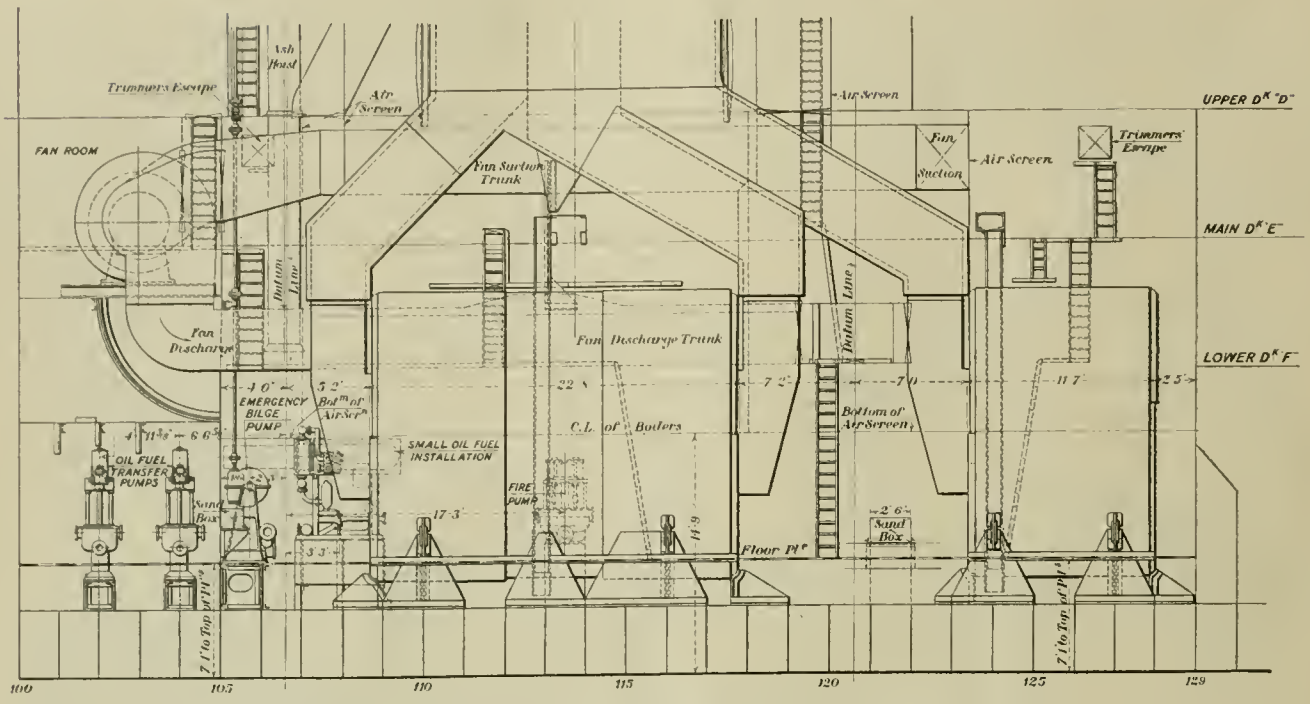
A thrust block of the Michell type is fitted immediately aft

(*Continued on page* 438.)

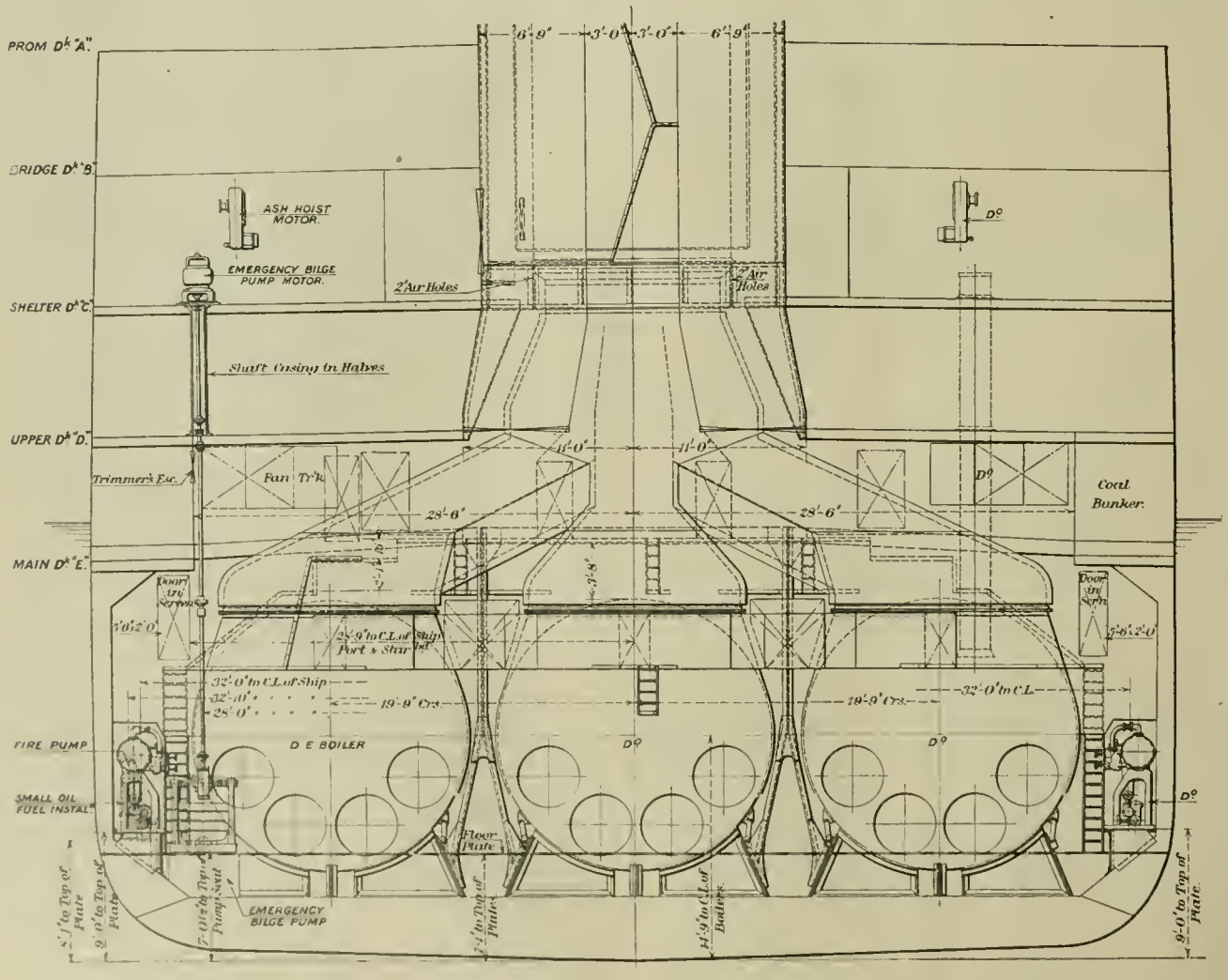


Elevations in Way of Machinery Space on the Fairfield-built "Tuscania."

THE NEW ANCHOR LINER "TUSCANIA." (See page 427.)



Elevation, looking to Port, showing Single and Double-Ended Boilers.



Cross Section at Frame 100, looking Forward, showing three Double-Ended Scotch Boilers.

THE LOSS OF THE "BEACON GRANGE."

Preliminary Survey—Salvage Labour Boycott—Salvage of 2,000 tons of Coal.

By the courtesy of Mr. Jas. Adamson, Hon. Secretary, Institute of Marine Engineers, we are able to publish some very fine photographs and a description of the stranding and supplementary salvage operations on the *Beacon Grange*. These photographs were received by Mr. Adamson from Mr. Herbert McLean, M.I.Mar.E., Consulting Engineer, Punta Arenas, who describes in a most interesting manner the difficult and hazardous salvage operations carried out with very scanty equipment. We feel we cannot do better than publish Mr. McLean's letter, verbatim, as follows :—

"I have pleasure in enclosing a few photos which perhaps will be of interest, and at the same time, will give you an idea of the work I occasionally come up against.

The "Beacon Grange" high and dry with Salvage Steamers "Rio Santa Cruz" forward, and "Antartico" aft.

"The ss. *Beacon Grange*, while on a voyage to Rio Gallegos, Argentine Republic, to load frozen mutton, ran ashore on Oliver Bank, at the mouth of the Rio Gallegos, during September, 1921. I was sent up there from Punta Arenas to survey her and see what could be done in the way of salvage. My first visit to the wreck was made partly in a tug, but as the tide was low the tugmaster would not put us alongside, so we embarked in one of the *Beacon Grange's* dinghies, which we had in tow, and finished the voyage in her. We landed on the west side of the bank, and, carrying our provisions, &c., trudged across the loose shingle for about half a mile to where the wreck was lying. There were several ropes dangling over the ship's side, and the captain started to climb up, but when he reached about the Plimsoll mark, the rope broke and down he came. Fortunately he fell on all-fours, and beyond a rough shaking up, he was none the worse for his drop of 25 ft. The next man to make the attempt got up without mishap, and he lowered a ladder for the rest of the party. By the time we got up, the tide had turned and was coming in very fast, so we had no time to lose.

Condition of Vessel.

"The *Beacon Grange* was a total loss. She started to break up the same night as she ran ashore, and rivets were bursting and flying about. The wood deck amidships was bursting and tearing away from its fastenings at each end of the deck houses. The ship's sides were bulging in places, and the bottom of the vessel, from the engine room to the No. 2 hold, had come up about 2 ft. 6 in., and all the stanchions in the holds were either broken or very badly twisted. The boilers had shifted, and the inner funnel was protruding above the outer casing. The main engines had come up, the main stop valve broken off, and all gratings were lying at most awkward angles, so that one had to be very careful in going down the engine room.

"The whole engine room was in a filthy mess. The tide rose to about 6 ft. above the cylinder tops, and the oil from the oil tanks, also from the bilges, had naturally floated up, as did also the charcoal insulation, smothering everything. You can imagine the feelings of an engineer accustomed to see a nice clean engine room, and then to witness such a transformation in so short a time. There was about 1 in. thickness of this charcoal and grease on the engine-room platform when the tide was low. On the tide rising again, the tug came alongside and we returned to Rio Gallegos, a good hour's run. Salvage steamers were sent for, and the Chilian steamers *Lovart*, *Antartico* and *Rio Santa Cruz* were despatched from Punta Arenas, and after the usual formalities were gone through, and permission obtained from the Argentine authorities, work was started. Salvage operations (confined to salving the coal cargo) were very difficult owing to weather and labour conditions, and the exposed condition of the *Beacon Grange*. There was a strike in progress in Punta Arenas, so the ships were manned with a miscellaneous crowd. We endeavoured to collect men in Gallegos, but found that the Federation in Punta Arenas had advised their friends in Gallegos, with the result that we were boycotted. However, we managed to secure the services of the Liga Patriotica, who supplied us with a crowd of free labourers (well armed) to discharge the salved coal on shore. We also arranged to get men to work on the wreck, but they were fired at on their way down to the steamer and two of them were wounded, fortunately only slightly. The others went home, so we started the work of shovelling coal ourselves, short-handed at first, but I got my boilermaker and mechanic squad on the job also. The *Beacon Grange's* winches were utilised, steam being supplied through flexible steam pipes, by whichever vessel happened to be alongside. We managed to salve about 2,000 tons of coal, besides a quantity of ship's gear, ropes, derricks, winches, pumps, anchors and chains, brass, copper pipes, &c., and we did not forget the gun. This gun was landed on condition that it was shipped to England at the first opportunity.

"The *Lovart* was the first vessel to arrive on the scene. She was very short-handed, but the *Antartico*, which arrived a few days after, was well manned in point of numbers, but they had no one on board who could cook. One of the *Lovart's* firemen, who happened to be a cabinet maker, was transferred to the *Antartico* as a cook. The change was a very fortunate one, as he turned out very well and everyone was satisfied. The *Rio Santa Cruz* was also well manned, so the work went on as well as could be expected under the circumstances. During the six weeks I was up there, I had good opportunities of taking the photos, and was also very interested in watching the destruction of the *Beacon Grange*. When the weather was bad, the after-part of the ship was on the move, and with every wave the torn and broken ironwork would scrape backwards and forwards with shrieks and groans as though in pain. Before I left her the stern had drooped about 25 ft., making the work of salvage from No. 4 hold very difficult, and from the No. 5 hold impossible.

Removing Auxiliary Machinery.

"In the engine room I had great difficulty in getting the pumps and gear out, as when the 'tween decks burst, the coal from the bunkers was washed down the engine room, burying the main engines to the height of the low-pressure cylinder bottom. All the piping was in a fearful tangle, and many of the boiler mountings were broken off the boilers. The screen bulkhead between the engine room and stokehold was very badly buckled, and the gauge columns were lying at an angle of 45 deg. to the vertical, and I was surprised to find that the glasses were not broken. The dynamo was lying up against the ship's side and most of the pumps were broken and standing at different angles.

"On three successive tides I had to dig away a few tons of coal in order to get at the feed pump which had been buried. The weather conditions were unfavourable most of the time, and when you consider that there is a rise and fall of 36 to 40 ft. and an 8 to 10-knot current, you will understand the arduous nature of our work. The beech was nice and flat when we first arrived, but it very soon altered in shape, making it dangerous for us to beach our vessels alongside the *Beacon Grange*. One morning we were discharging and, as the weather seemed fine, we decided to lie alongside, but when the tide went down and our vessel grounded, we noticed a most pronounced vibration when the winch was working. After our vessel got dry we went down on the beach to investigate, and found that the beach had so altered that our vessel was only resting in places, so we had to hustle and block her up as though she were on a slipway, using hatches and any other wood we could lay our hands on. On another occasion, we were lying alongside with a falling tide when the wind changed and we had to try and clear out. On going astern with our engines, our stern was driven unpleasantly close to the wreck, and there was a chance of our little *Rio Santa Cruz* being washed over the well-deck on top of the No. 5 hatch of the *Beacon Grange*.

"As the tide was falling rapidly and the wind freshening, we had no alternative but to go full speed ahead and jump the bank, which we succeeded in doing, with only a couple of slight bumps.

"On another occasion we were stuck alongside and could not get away. The weather was frightful, so we had to put out extra fenders and extra mooring ropes and wires and hang on all night, with our engines going ahead. In the meantime, we were receiving seas over our decks, and at times, it was impossible to see our fo'c'sle head for spray. The waves and the backwash from the beach made our vessel range backwards and forwards from 10 to 15 ft. in spite of the engines going ahead. Several of the mooring ropes snapped (we had four forward and four aft in addition to our anchor and chain), and it was wild work replacing them. We did not sleep that night, and we were all pleased when our vessel started bumping and we knew our watch was over as she would soon be high and dry and ready to receive more cargo. On the whole, our efforts were not very successful, although we were struggling as well as possible to save what we could in as short a time as possible, but the drop in the price of coal reduced the value of our work, and we did not get back to Punta Arenas in a very satisfied frame of mind. However, it was soothing to our feelings to be told in Rio Gallegos that they were surprised we had 'stuck it' so long.

The Salvage Expedition.

"The expedition was under the command of Captain A. C. Jensen, a Danish captain of great experience, and I often admired the skilful seamanship he displayed in laying his vessels alongside the *Beacon Grange*, with wind and sea and a 10-knot current running broadside on. The captain of the *Antartico*, also a Dane called Jensen, is also a very skilful seaman, and it is a pleasure to work with them. The more difficult the work, the more they rise to the occasion, never beaten. Just as our work on the *Beacon Grange* was drawing to a close, we had news of the stranding of the motorship *Lima*, on the other side of the continent, and that a salvage expedition had been despatched by our firm. We were, of course, disappointed at not being there, as Captain A. C. Jensen and myself are generally in charge of these expeditions, in the absence of the Marine Superintendent, Captain F. Willumsen. However, we couldn't be in two places at once, so the *Lima* was attended to by others. Should you consider these photos of sufficient interest for publication, I would be very pleased to lend you the films.

"About ten days after my return to Punta Arenas, the *Lima* arrived, and I took charge of the repairs. These were effected on the beach at Punta Delgada, Straits of Magellan, about 60 miles to the North of Punta Arenas, and were of a very arduous and responsible, but interesting nature. I hope to send you a few lines and a number of photos on these repairs, which were unique."

Director of Cast-Iron Research Appointed.—The Council of the British Cast Iron Research Association have offered the important position of Director of Research to the Association to Dr. Percy Longmuir, of Sheffield, which he has accepted, and will take up his duties on November 1. Dr. Longmuir is recognised as one of the foremost foundry experts in the country, and this appointment has given the greatest satisfaction to the cast-iron industry with which he has had a life-long connection. There is no doubt that the Council of the Association could not have made a better choice, as, in Dr. Longmuir, ironfounders will have that confidence that will tend to the future success of the Association. Dr. Longmuir is a Carnegie Research Medallist and a large contributor to technical literature upon foundry work.

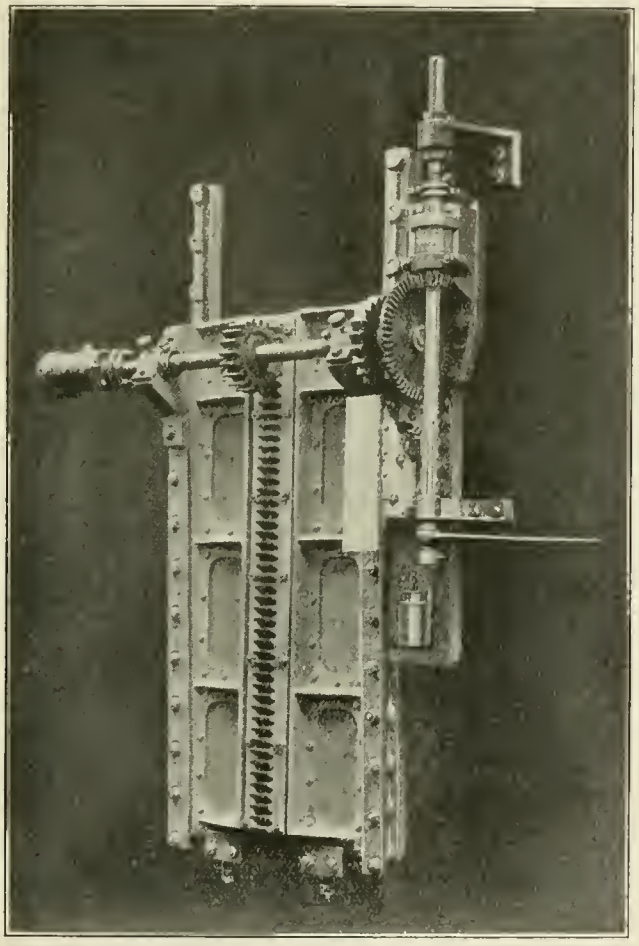
"Mauretania" Repairs.—The Cunard liner *Mauretania*, which arrived at Southampton early last month, underwent repairs to the port low-pressure turbine which had been shut down during the two previous voyages. These repairs were carried out by J. I. Thornycroft & Co. Ltd.

Conversions to Oil-Burning.—Among contracts given out lately for installation of Todd Mechanical Fuel Oil Burners are the Red Star liner *Kroonland*; United Fruit Company's steamers *Calamares*, *Pastores*, *Simon*, *Esparta*, and *San Jose*; and the Southern Pacific Morgan Line vessels *El Sid*, *El Siglo*, *El Dia*, and *El Rio*. The work is divided between the two Todd Corporation yards, Robins' Dry-dock, Brooklyn; and Tietjen & Lang, Hoboken, New Jersey.

A NEW WATERTIGHT-DOOR RELEASING GEAR.

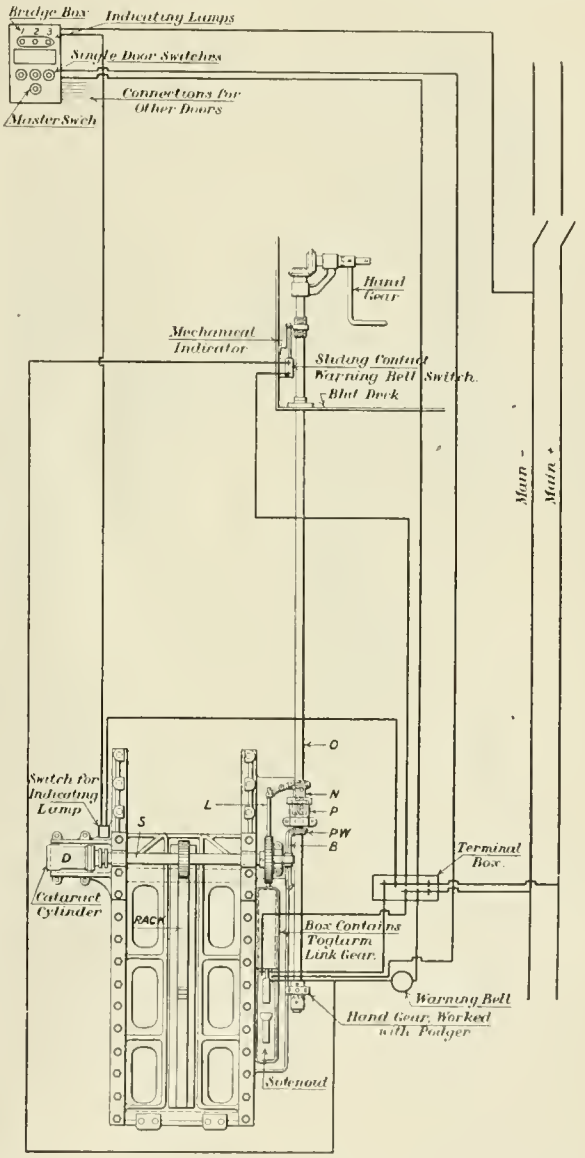
Board of Trade Requirements—The New Gear Described—Indicating and Alarm Arrangements.

Recent marine casualties have again served to focus attention on the question of life-saving and safety appliances on board ship, and of such safety appliances the watertight door is not the least important. The Board of Trade requirements for watertight doors and their manipulation in the case of passenger ships are definite and, on the whole, simple. Six types of door, in all, are defined by the Board of Trade, and Type VI consists of a sliding door worked by power-pressure gear and complying with several other requirements which



Mechans' Watertight Door with "Toglarm" Releasing Gear.

generally make for additional weight and expense. This type of door, however, is obligatory in two special cases only, the first of which has reference to doors which, situated below the bulkhead deck, have sometimes to be open at sea for coal trimming between bunkers. In the second case, Type VI must also be fitted in trunkways for refrigerated cargo where these trunkways pass through more than one main transverse watertight bulkhead in certain positions. For all other purposes, and in practically any ship, however large, Type V, and in some cases even Type IV, is sufficient. Doors coming under the category of Type IV should be sliding doors which can close with their own weight and can be released at the doors themselves. It should also be possible to release this door from the bulkhead deck and, in the event of failure to close when released, the door should be closeable by hand from a position above the bulkhead deck and also at the door itself. A cataract arrangement should be provided to control the speed of closing, and audible warning should be given when the door is about to close. Finally, an index should be provided at some position above the bulkhead deck to indicate clearly whether each door is open or closed.

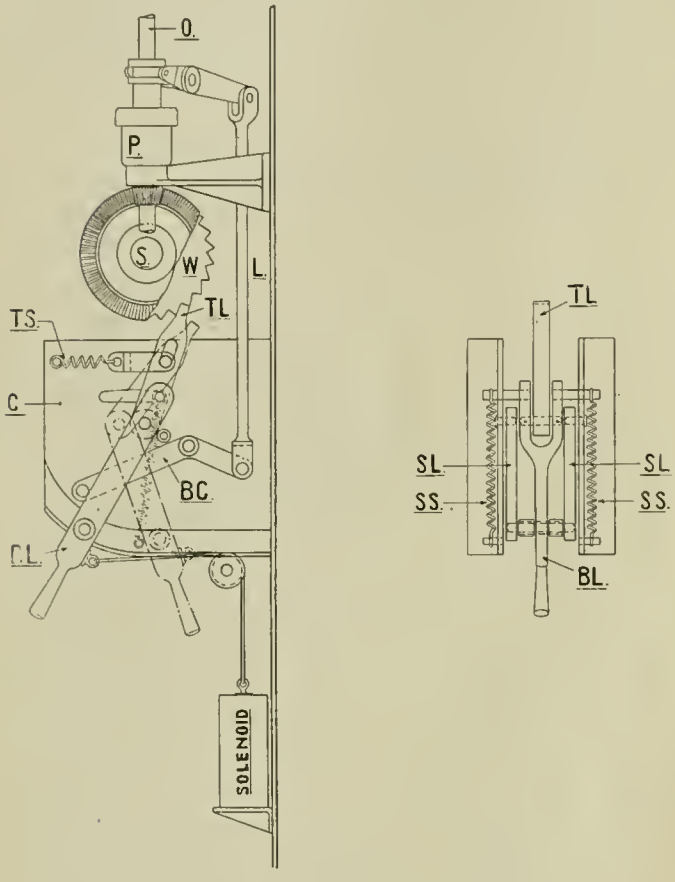


Diagrammatic Arrangement of Door, with Wiring and Hand Controls.

Doors satisfying the requirements of Type V are in all respects similar to those of Type IV with two exceptions. These two exceptions have reference, in the first place, to the fact that the release gear must be workable from the bridge, and secondly, that an additional indicator should be provided at the bridge, showing whether each door is open or closed.

A new type of gear has been devised with a view to fulfilling the requirements for doors of Types IV and V, and in the drawing on the next page we illustrate this "Toglarm" gear which has been designed by Mechans Limited, of Glasgow. The shaft S carries a pinion which engages with a rack on the door and, as the door closes, this shaft rotates in a clockwise direction.

A ratchet wheel W is also keyed to the shaft S. The casing C contains four links, a top link TL, a bottom link BL, and two side links SL. As will be seen from the drawing, the links TL and BL form a toggle joint, and the full lines in the drawing represent the "shut" position. The top link TL performs the additional function of a pawl and engages with the ratchet wheel W, preventing this wheel from rotating in a clockwise direction, which is equivalent to keeping the door open.



Details of Mechans' "Toglarm" Releasing Gear.

The side links hinge on pins carried by the side plates, and the centre line of these pins is concentric with the pin, uniting the top and bottom links when the toggle is "shut." From this arrangement it will be seen that the bottom link may be swung without raising or lowering the top link, so that the toggle may be moved from the "shut" to the "open" position with the minimum of exertion. During the movement from "shut" to "open" the toggle "tumbles" and the links assume the positions shown by the dotted lines. This brings the top link clear of the ratchet wheel W which, being now free to rotate, permits the closing of the door. A horizontal spiral spring TS draws back the top link when the gear is being reset and allows the top link to act as a pawl when the door is being opened and the ratchet wheel is rotating in an anti-clockwise direction. Two side springs SS lock or restrain the toggle in each position. The solenoid shown is only fitted in the case of Type V doors. This solenoid is energised from the bridge and gives ample power to operate the gear.

On page 435 we show a front view of the door from which the arrangement of the gear will be readily seen. Mounted on the shaft S is a bevel wheel B which engages a pinion wheel PW, to which is secured a pot P. An operating shaft O threaded at the bottom and engaging a nut N, is led up from the bottom of the pot. When the shaft O is rotated the nut N is prevented from turning, travels down the shaft, and in so doing operates the lever L. This lever in turn rotates the bell-crank lever BC, shown opposite, thereby opening the toggle and releasing the door. Should the door not close, further rotation of the shaft O forces the nut N to "bottom" in the pot causing the shaft and pinion wheel to become united and the door is forced down by hand. The dash pot D, shown at the other end of the shaft S, although not an integral part of the releasing gear, constitutes a convenient and compact form of cataract which embodies a device whereby the rate at which the door closes may be varied from point to point.

The shaft O is extended from above the bulkhead deck to the door itself so that the door may be operated by hand from either point. The illustrations given refer to a vertical watertight door, but the gear is equally applicable to a horizontal door, in which case a vertical shaft and a weight, acting through a chain and wheel, are provided. When the electric switch on the bridge is closed, current from the ship's generators is allowed to flow round the solenoid, which then operates the "Toglarm" mechanism. At the usual ship's voltage of 110, only 10 amperes per door is required, so that the wiring should present no difficulties. The switch on the bridge is so arranged that the doors may be closed individually or collectively, and the time required for the solenoid to operate the release mechanism is stated to be less than one second.

Indicating gear is provided on the bridge at a point adjacent to the switch gear, and this indicating gear is also electrically operated. The position of each door is indicated diagrammatically in a key plan of the ship so that, where a door is closed, a light shines through the appropriate indicator and remains visible until the door is again opened. The sound-alarm gear may be placed, as required, at the door itself. This gear is brought into operation as soon as the bottom link is moved and causes a loud gong to sound, thereby giving warning to anyone in the vicinity of the door. It is claimed by the makers that the "Toglarm" gear compares favourably as to cost, simplicity and space occupied, with any other operating gear designed for doors of Types IV or V.

Stephen-Sulzer Two-Cycle Marine Diesel Engine.

(*Continued from page* 425.)

0·895, a flash point of 160-170 deg. Fahr., and a calorific value of 19,300 B.Th.U. per pound. Its viscosity was 235 sec. at 70 deg. Fahr., and its sulphur content was 0·8 per cent. From these results it will be observed that the fuel consumption on a brake horse-power basis is comparatively high, a fact which is partly explained by the low temperature of the jacket cooling water, the outlet temperature from the cylinder covers being about 90 deg. Fahr. at 9/10 full load. The lubricating oil consumption is also substantially above even normal service requirements, but as the engine was new and under initial test a very liberal oil supply was given all bearing surfaces. A brief analysis of fuel and lubricating oils as used in the test is given in the table of results. The results of these trials have been regarded by all concerned as highly satisfactory.

WAR MEDALS FOR THE MERCANTILE MARINE.—Medals are now ready for issue to persons in possession of Forms of Authority to wear the Ribands, dated prior to September 30, 1922. Application should be made on the prescribed form, which can be obtained at any Mercantile Marine Office, or direct from the Mercantile Marine Department, War Medals Branch, Cornwall House, Stamford Street, London, S.E.1.

N.H.P. AND HEATING SURFACE OF BOILERS.

Relationship existing between the Nominal Horse-Power of Boilers suitable for a Given Size of Engine.

In the article, "Cargo Boat Machinery—II,"* which we published in our May issue, we gave Table II, compiled on the basis of the 1917 Rule, issued by the North-East Coast Institute Guidance Specification for Triple-Expansion Engines for Cargo Vessels, also Table III, compiled on the basis of the 1919 set of Rules, issued by the same authorities.

To find the nominal horse-power of the boilers suitable for a given size of engine, use Lloyd's Rule, as follows :—

$$\text{N.H.P.} = \frac{\text{W P} + 590}{1500} \times \frac{\text{H S}}{\text{C}} \times 2$$

boilers, the heating surface being calculated by the following rule as a basis :—

$$\text{H S} = \frac{\text{D}^2 \times \text{L}}{1 \cdot 1}$$

where H S = Heating surface in square feet.

D = Diameter of boiler in feet.

L = Length of boiler in feet.

Note.—Lloyd's nominal horse-power for engines and boilers,

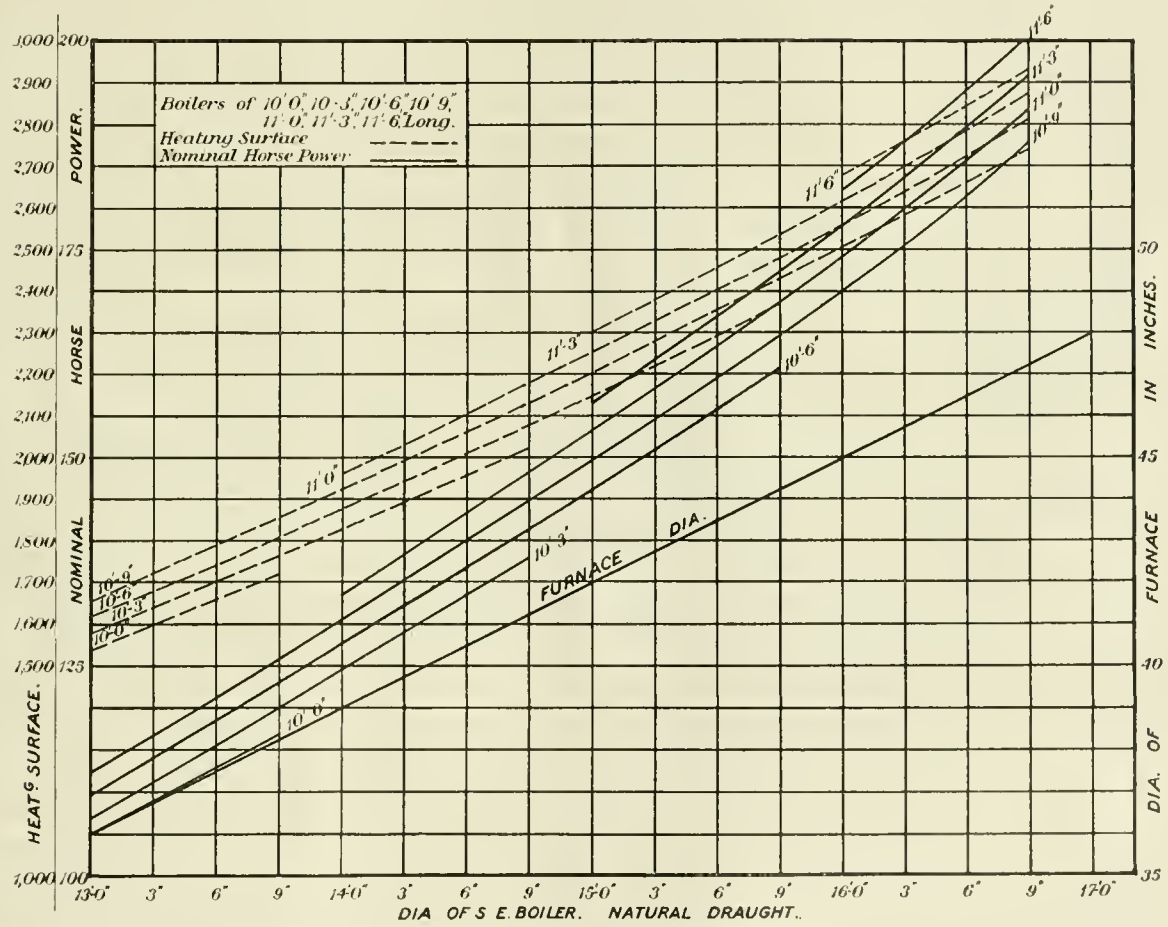


Diagram showing Diameter of Furnace, N.H.P., and Heating Surface for Three-Furnace, Natural Draught Boilers.

Where N.H.P. = Nominal horse-power.

W P = Working pressure in lbs. per square inch.

H S = Heating surface contained in the boiler down to the level of firebars, excluding the front tube plate.

C = Constant divisor for natural draught boilers.

Table IV, on page 138, has been compiled on this basis, the sizes given being the usual range adopted with three-furnace

* See *The Marine Engineer and Naval Architect*, May, 1922, page 177.

although only used in fixing the fees payable to their Society, can be utilised in comparing the relation which they bear to each other of their respective powers.

It is the common practice with some firms, when powering tramp steamers, to balance these powers, but never to put in a boiler with less N.H.P. than the engine when fitted in a bluff steamer.

Take as an example the first size of engine in Table II, as per 1917 Rule, as follows :—

Cylinders, 19½ in.-32 in.-53 in. × 36-in. stroke ; 75 revolutions per minute ; 30 lbs. referred mean pressure to L.P. cylinder ; 180 lbs. working pressure ; 904

Table IV.—180-lb. Working Pressure.

Nominal Horse-Power of Three-Furnace Boilers, Natural Draught.

Diameter. Boiler.	Furnace.	Length of Boiler. ft. in. 10 0	ft. in. 10 3	ft. in. 10 6	ft. in. 10 9	ft. in. 11 0	ft. in. 11 3	ft. in. 11 6
ft. in.	ft. in.	N.H.P.:						
13 0	3 0	105·0	107·5	110·0	112·5	—	—	—
		H.S.:						
		1,540·0	1,580·0	1,615·0	1,650·0	—	—	—
13 3	3 0¾	109·0	111·5	114·5	117·0	—	—	—
		1,600·0	1,640·0	1,680·0	1,720·0	—	—	—
13 6	3 1½	113·0	116·0	119·0	121·5	—	—	—
		1,660·0	1,700·0	1,740·0	1,780·0	—	—	—
13 9	3 2¼	117·0	120·0	123·0	126·0	—	—	—
		1,720·0	1,760·0	1,800·0	1,850·0	—	—	—
			N.H.P.:					
14 0	3 3	—	124·5	127·5	130·5	133·5	—	—
			H.S.:					
		—	1,830·0	1,870·0	1,920·0	1,960·0	—	—
14 3	3 3¾	—	129·0	132·0	135·0	138·5	—	—
		—	1,890·0	1,940·0	1,985·0	2,030·0	—	—
14 6	3 4½	—	133·5	137·0	140·0	143·5	—	—
		—	1,960·0	2,010·0	2,055·0	2,105·0	—	—
14 9	3 5¼	—	138·0	141·5	145·0	148·0	—	—
		—	2,025·0	2,080·0	2,130·0	2,175·0	—	—
				N.H.P.:				
15 0	3 6	—	—	146·0	150·0	155·0	156·0	—
				H.S.:				
		—	—	2,145·0	2,200·0	2,245·0	2,290·0	—
15 3	3 6¾	—	—	151·0	155·0	158·5	162·0	—
		—	—	2,220·0	2,275·0	2,325·0	2,380·0	—
15 6	3 7½	—	—	156·0	160·0	163·5	167·0	—
		—	—	2,290·0	2,350·0	2,400·0	2,455·0	—
15 9	3 8¼	—	—	161·0	165·0	169·0	173·0	—
		—	—	2,360·0	2,420·0	2,430·0	2,530·0	—
					N.H.P.			
16 0	3 9	—	—	—	170·5	174·5	178·5	182·5
					H.S.			
		—	—	—	2,505·0	2,560·0	2,620·0	2,680·0
16 3	3 9¾	—	—	—	176·0	180·0	184·0	188·0
		—	—	—	2,585·0	2,640·0	2,700·0	2,760·0
16 6	3 10½	—	—	—	182·0	186·0	190·0	194·0
		—	—	—	2,670·0	2,730·0	2,790·0	2,845·0
16 9	3 11¼	—	—	—	188·0	192·0	196·5	201·0
		—	—	—	2,760·0	2,820·0	2,880·0	2,950·0

indicated horse-power; 173 Lloyd's nominal horse-power.

Referring to Table IV (Nominal Horse-Power of Boilers), which gives the size of boiler as 15 ft. 9 in. diameter, and 11 ft. 3 in. long; diameter of furnace, 3 ft. 8¼ in.—

Heating surface in square feet

$$= \frac{D^2 \times L}{1 \cdot 1}$$

$$= \frac{15 \cdot 75^2 \times 11 \cdot 25^2}{1 \cdot 1}$$

$$= 2530 \text{ sq. ft.}$$

Heating surface per I.H.P.

$$= \frac{2530}{904} = 2 \cdot 81.$$

This result, 2·81 sq. ft. H.S. per I.H.P., is allowance obtained on trial, which would be considered insufficient for a cargo steamer. the cut-off chosen—57 per cent.—should be reduced by linking up, which will reduce the I.H.P., at the same time increasing the H.S. per I.H.P.

If the increased allowance is not considered sufficient to give the required economy in coal consumption per I.H.P. per hour, the size of the boiler will require to be increased to give the H.S. in sq. ft. considered necessary to effect the desired result.

This balancing of the power of an installation can be checked by reference to *Lloyd's Register* and getting out the particulars therein given of any particular ship, by the rules given.

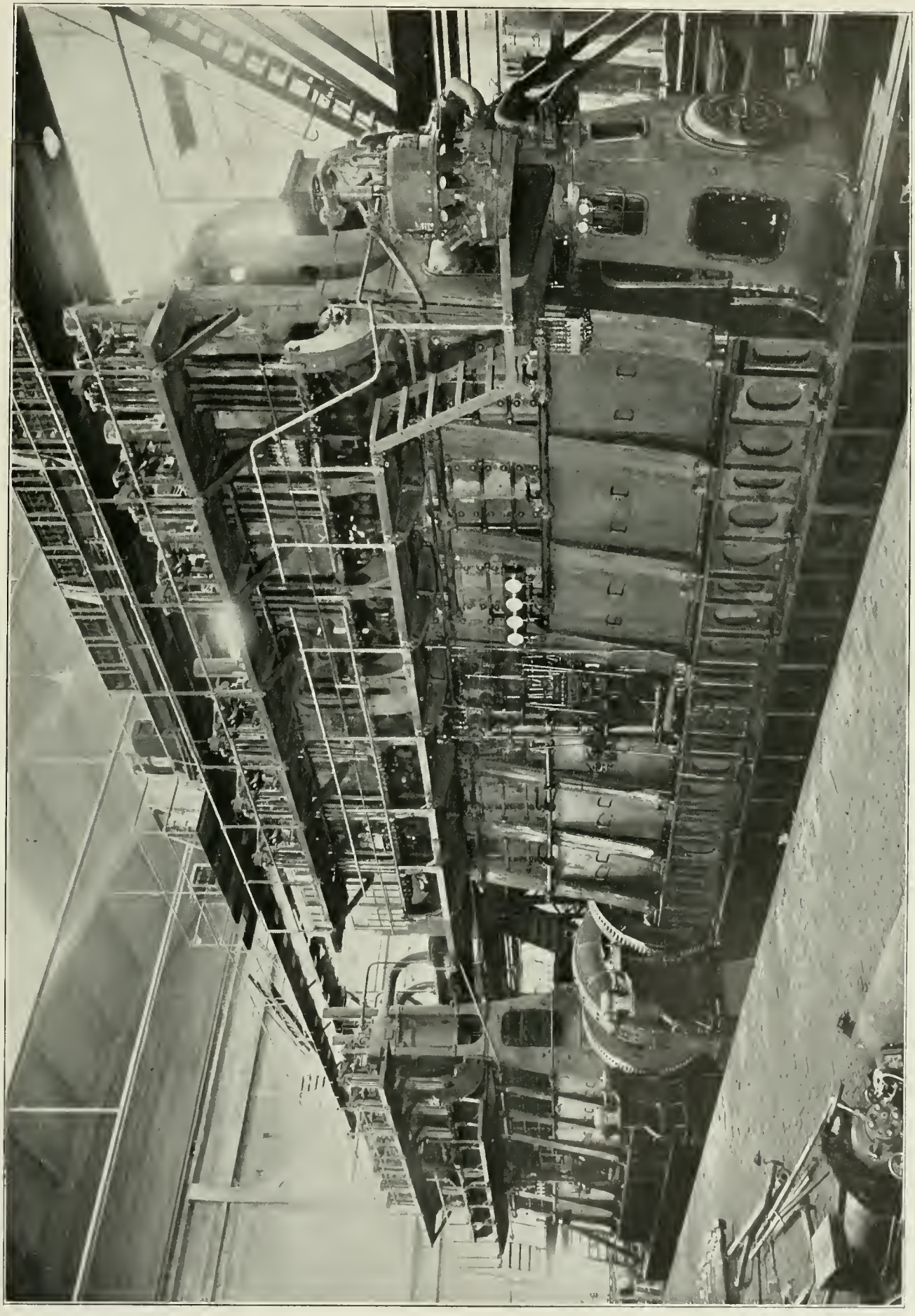
$$\text{N H P.} = \frac{\text{W P} + 590}{1500} \left(\frac{\text{L}^2 \sqrt{\text{S}}}{100} + \frac{\text{H S}}{15} \right)$$

THE NEW ANCHOR LINER "TUSCANIA"—(*Concluded from page* 431).

of each gear wheel to take the propeller thrust. The bearing pads are mounted on a spherically seated ring in order to equalise the load on each pad. Weir's closed circuit feed system is installed for returning the condensate to the boilers. Two turbo-extractor pumps discharge the feed water through a special surface heater, through which the exhaust steam from the air ejectors passes, thence to the main feed pump, which is of the centrifugal type, turbo-driven, and through the surface heater to the boilers. A special surface condenser is fitted to deal with the mixture of air and exhaust steam from the air ejectors after it has passed through the special surface heater. Two Weir's vertical simplex pumps are fitted for auxiliary purposes and as standby to the rotary pump. The whole of the auxiliary exhaust steam from the reciprocating pumps passes through the surface heater and also sufficient of the clean exhaust from the turbo-auxiliaries, including the generators, to raise the feed temperature to the desired degree, the remainder of the clean exhaust being led to the second stage of the L.P. turbines and the heat extracted by doing useful work. There is also fitted, to deal with these ship service drains, a separate drain condenser with combined air and circulating pump, by Messrs. Carruthers.

The forced lubrication system is supplied by oil from two of three Weir's pumps, the third pump being a standby. Oil to the bearings passes through one cooler, while the sprayer oil passes through two coolers, in series, making eight passes in all, thereby increasing the viscosity of the oil, a most desirable condition with turbine gearing. Gravity tanks are placed in the engine-room hatch which come into use in a case of emergency. For cleansing the oil, a De Laval purifier has been installed which deals with heated oil and returns it clean to the drain tank. Magnetic strainers, manufactured by Smith, Lemon & Stewart Limited, Newcastle, are fitted on the pump suction, for removing all iron particles.

Generally, the auxiliary machinery may be said to be most comprehensive, and all connections have been so arranged that a failure in any one system can readily be dealt with by another. The ballast, bilge and sanitary systems have each at least one pump electrically driven. There are also fitted steam duplex pumps for the ballast, bilge, fresh water and hydraulic watertight door systems. A complete auxiliary plant for harbour use has been installed, including condenser, air ejector, drain tank, circulating pump, filter and float-control tank. For make up feed, and for fresh water for ship purposes, two evaporators and one distiller are supplied, each capable of making 50 tons of water per day. Two Metropolitan-Vickers 375 k.w. geared turbo-generators are placed between the main thrust blocks, and on the starboard side of the engine room Hall's CO_2 refrigerating plants, complete with electrically-driven compressors, circulating pump and brine pumps, are fitted.



Two Sets of Burmeister & Wain Six-cylinder Four-Cycle Diesel Engines for the "Tennessee," of 11,000 tons d.w., built for W. Wilhelmsen, Tonsberg. (See page 418.)

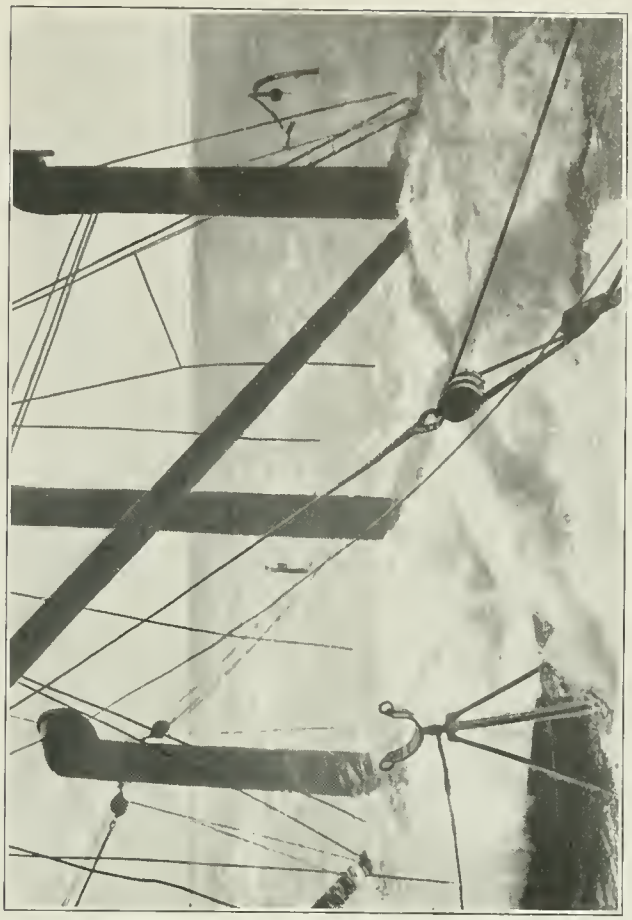
The "Beacon Grange" high and dry on Oliver Bank.

Position of the Vessel as found at High Tide.

Vessel's back broken, and SS. "Antartico" grounded Alongside.

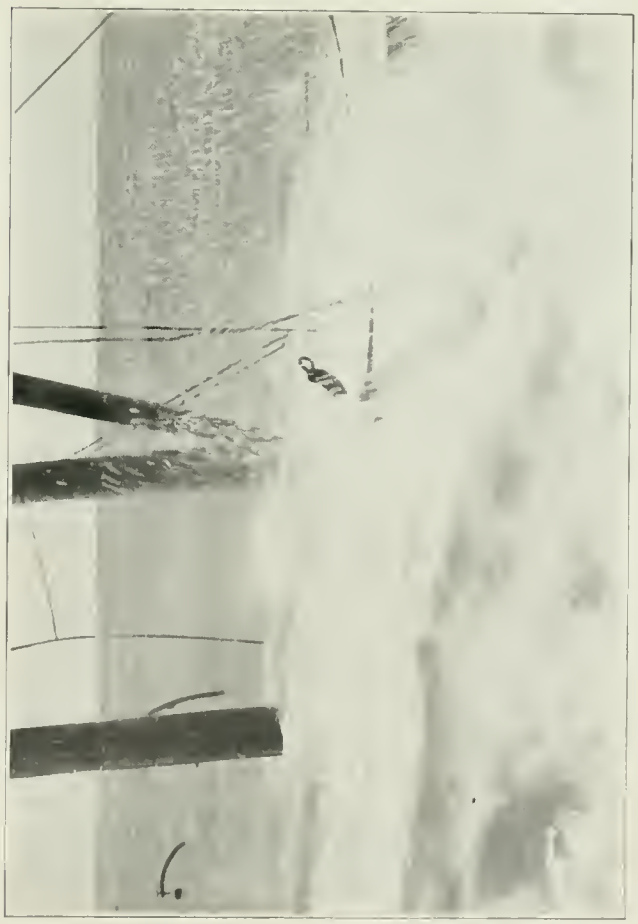
Port Side at Low Tide, showing Fractured Plating.

Tide rising over Poop. Well-Deck Submerged.



No. 4 Hatch at High Tide.

After-Deck Boats washed away from Poop.



No. 4 Hatch Completely Submerged.

A NEW CENTRIFUGAL ANTI-PRIMING STEAM DRYER.

Disadvantages associated with Priming—Principle of Tompkin's Dryer—Test Results and Characteristic Curves.

There are few things better calculated to disturb the peace of mind of the average sea-going engineer than a priming boiler, and should there be one special vessel in a fleet of steamers which is particularly susceptible to priming, that vessel very soon becomes known as a "wet" ship and one for which the

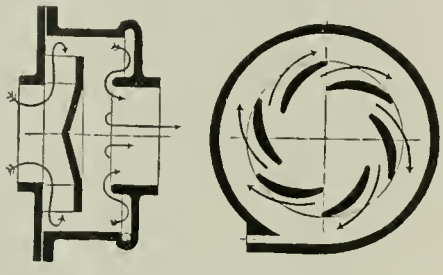


Fig. 1.—Sectional View of Centrifugal Dryer.

engineers of the company manifest but little liking. While a variety of theories have been advanced in explanation of the phenomena underlying priming, and opinions may differ as to the actual cause, engineers as a whole are more or less agreed as to the very undesirable effects of priming. Two sister vessels may be built by the same shipbuilder and may be as nearly alike as human skill can devise, yet one may be a "wet" ship and the other a dry one. It has been by no means uncommon for a vessel's speed to have been compulsorily reduced to less than half the normal full speed when encountering a head or a beam sea, due to abnormal priming, with the consequent menace to the cylinders and the gland packings of a reciprocating-engined vessel, to the blading

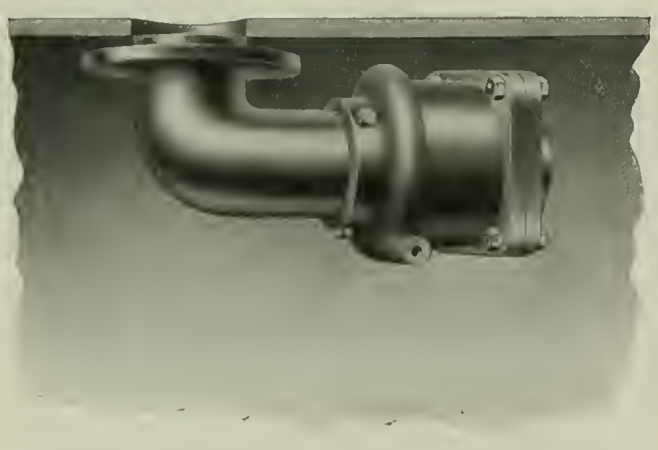


Fig. 3.—Method of Attachment to Shell of Scotch Marine Boiler.

if a turbine-driven ship. Apart from the serious damage, such as the destruction of metallic or fibrous gland packings, the scoring of piston rods and cylinders and the erosion of turbine blading, which is likely to follow active priming, the compulsory slowing-down of a vessel at sea may seriously interfere with her cargo commitments and involve the owner in heavy loss.

There are, however, several other very undesirable features associated with priming. It is generally agreed by engineers—and the trend of modern practice bears it out—that the utilisation of higher degrees of superheat is likely to be attended with a marked increase in economy. Every type of steam boiler generates, to a greater or a less degree, steam containing moisture, and the proportion of this moisture to the total steam generated varies approximately from 2 to 6 per cent.,

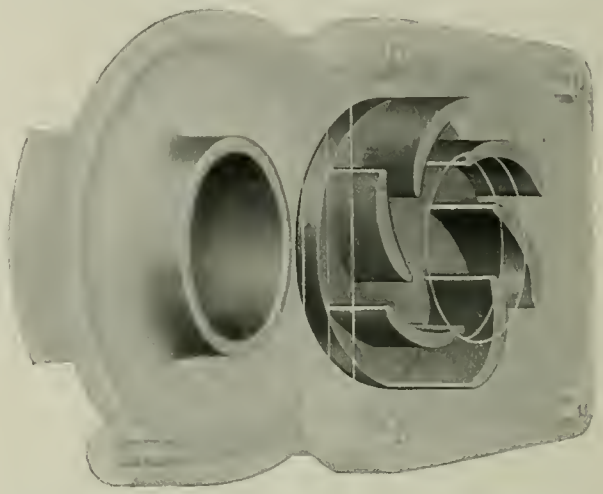


Fig. 2.—Phantom View, showing Arrangement of Guide Vanes.

according to the conditions of firing and the height of water carried in the boiler. Where priming occurs, this percentage of moisture is, of course, enormously increased, so that it becomes evident that much of the economy of superheating will be lost if, in the first place, the superheater is supplied with steam containing a high percentage of moisture. It has

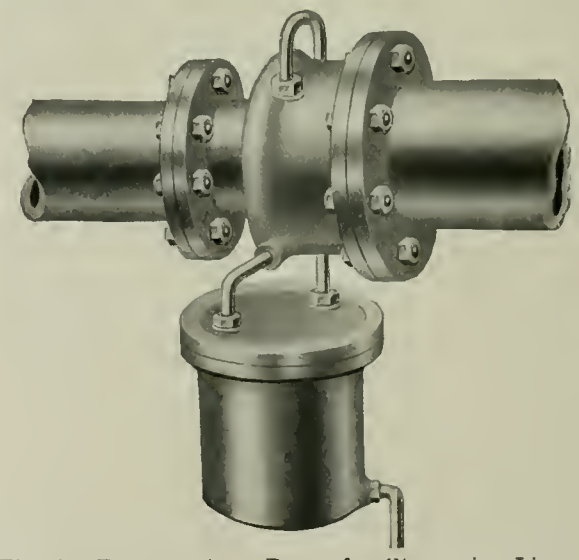
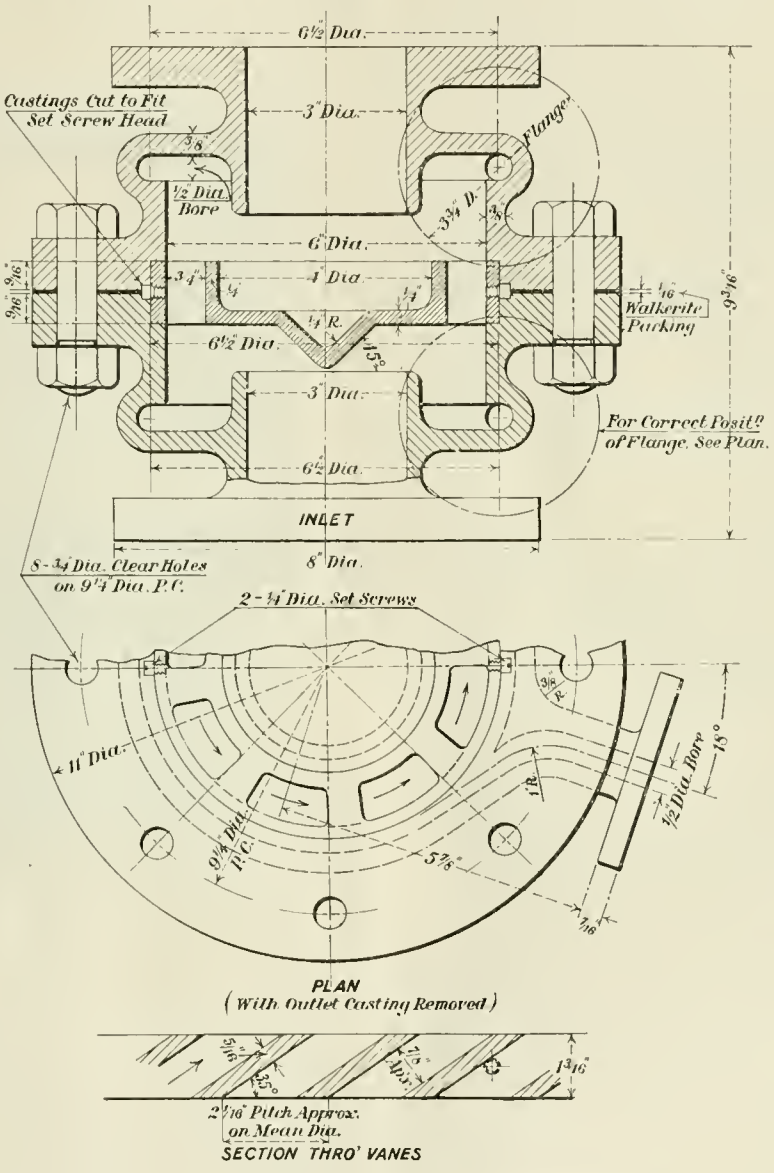


Fig. 4.—Pressure-type Dryer for Steampipe Lines.

been estimated that every 1 per cent. of water carried over with the steam represents approximately the equivalent of 1 per cent. more fuel, so that, apart from the structural damage already outlined, it will be seen that dry steam is a very important factor in reducing fuel consumption.

Many devices have been introduced from time to time for the prevention of priming, but so far as the actual elimination

of priming is concerned, the majority of these devices have been attended by only a limited measure of success. Some of these have been heavy and costly and, in some cases, have actually aggravated the priming by reason of their design, whereby an action closely analogous to that of a syphon was set up. In this article we propose to deal with an entirely new form of anti-priming and steam drying device which has recently been applied ashore and afloat with a substantial measure of success. The Tompkin's Patent Tangential Dryer, which we illustrate in Figs. 1 and 2, is an extremely simple and compact apparatus. This dryer consists essentially of two distinct castings, *i.e.*, a nozzle plate or deflecting chamber, which gives to the steam and moisture a whirling motion, and a collecting chamber in which the moisture and steam are caused to separate. The principle on which this dryer functions will be readily understood by reference to Fig. 1. Boiler steam enters in the direction as shown by the arrows and is brought into immediate contact with guide vanes, which cause the axial steam flow to be diverted into a circumferential flow. These guide vanes are mounted on a conical base with the apex of the cone facing the entering steam. Owing to its greater density, the contained moisture is caused to move radially outwards by the action of centrifugal force and, clinging to the inner periphery of the separating chamber, is ejected by way of the tangential discharge as shown in Figs. 1 and 2. The formation of these blades is such as to set up a vortex action in the chamber, and the tangential outlet for the separated water is so situated as to arrest this water at its maximum velocity. Visible proof of the action of this dryer has recently been found in the case of boilers opened up for survey, when a clearly defined, polished metallic ribbon was seen on the inner boiler shell, due to the scouring action of the water and foreign matter ejected by way of the tangential outlet.



Tangential Dryer as applied to Steam Whistle.

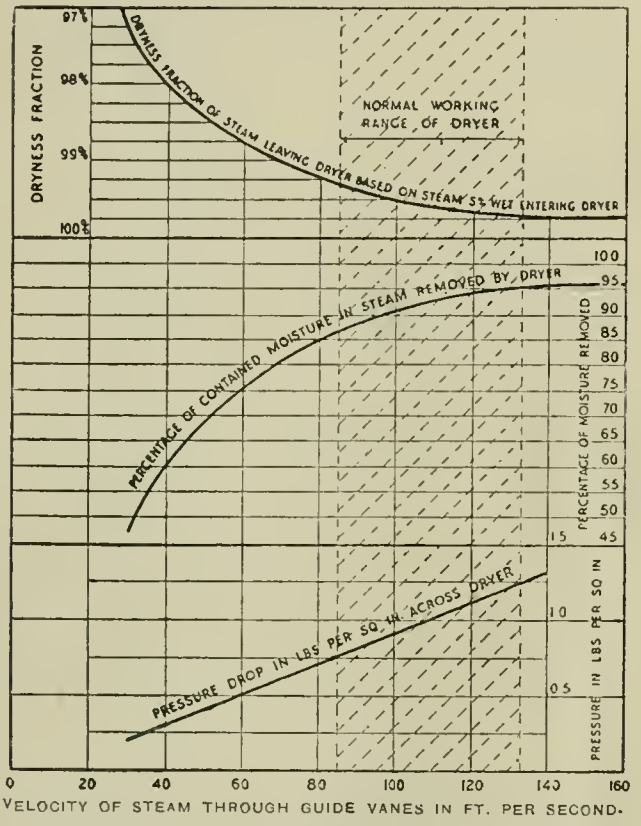
In Fig. 3 we show one method of attaching the Tompkin's dryer to a Scotch marine boiler where the main stop valve is mounted on the shell. The dryer may be adapted for the case where the stop valve is in the end-plate and is, moreover, equally adaptable to locomotive, Lancashire or water-tube boilers. Its compact nature is such that it can be easily passed through a standard 15-in. by 11-in. manhole door. It is claimed that the fitting of this dryer dispenses completely with the necessity for an internal, slotted steampipe, but in cases where this steampipe is already fitted, it may be, if desired, attached to the spigot of the dryer. At maximum designed output the pressure-drop across the dryer does not exceed 1 lb. per square inch, and the average drop in practice may be said to amount to about one-half per cent. of the boiler pressure. Its advantages will be found to apply whether saturated or superheated steam is used, and in the case of superheaters, in addition to the advantage of initial dry steam supply, as already referred to, choking of the tubes and deposit is avoided, since all foreign matter, sediment, &c., is ejected through the tangential discharge. The compact design and the fact that this dryer can be accommodated close to the steam-drum shell, render it particularly suitable for water-tube boilers with their restricted steam space, and all danger of syphoning is thus eliminated.

Apart from its application to steam boilers, the dryer has also been applied successfully for the removal of condensation in extended lengths of steam piping. Such an application is illustrated in Fig. 4, where the dryer is shown in conjunction with a steam trap. For this purpose, the dryer is exactly similar to the boiler type, except that the casing must, in this particular case, be designed to withstand the full boiler pressure. The separated moisture leaves the steam trap by a drain pipe, which may be led to the most convenient point for recovery.

A further application of the Tompkin's dryer, and one in which a great measure of success has been achieved, is in conjunction with steam whistles. For this purpose it is fitted immediately under the whistle or under the Willett-Bruce control. We produce on this page a drawing showing a 3-in. dryer as recently applied to the steam-whistle equipment of a large trans-Atlantic liner. As will be seen, there are, in this case, two drains. The upper tangential discharge is used when the whistle is blown and the lower is used when the whistle is not in use. Both discharges are connected to a common drain pipe, and the water is recovered at the most suitable point. A remarkable improvement has been observed following the application of these dryers, the whistle, at the first pull of the lanyard, emitting a clear sharp note with only a light vapour visible, which is in marked contrast to the not unusual shower of scalding water. It is understood that the dryer has also been successfully applied in compressed-air services for the removal of water accumulation in pipes and other parts of the system

and, in this way, freezing, with its resultant stoppages and repairs, has been avoided.

We show on this page a series of curves based on experiments recently carried out at University College, Southampton, with a 2-in. Tompkin's dryer of the pressure type. These curves are self-explanatory. With a mean steam velocity of 100 ft. per second through the guide vanes, the corresponding pressure-drop across the dryer will be 0·9 lbs. per square inch. If the steam entering contains 5 per cent. of moisture then 91 per cent. of this contained moisture will be extracted by the



Characteristic Curves from Tests carried out with a 2-in. Dryer at Southampton University.

dryer, the steam finally leaving the dryer 99·6 per cent. dry as against 95 per cent. dry initially.

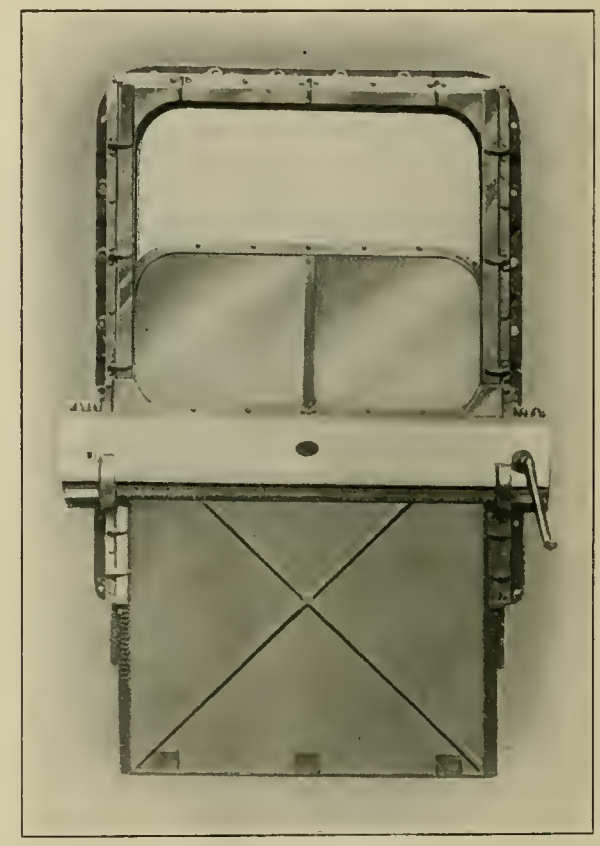
It has sometimes been asked what effect excessive forcing of the boiler would have on the action of this dryer. The greater the degree of forcing the greater will be the volume of steam passing through the dryer in a given time, so that the peripheral speed of the steam passing the vanes will be correspondingly increased and the rate of water separation will automatically rise to suit the steaming conditions. The Tompkin's dryer has already been fitted to vessels representative of the largest steamship companies in the world, and many reports as to the improved conditions have been received from chief and superintendent engineers. Tompkin's Dryers Limited, of 195, Strand, London, W.C.2, hold the world's patent rights for the Tompkin's dryer.

Engineering Appointment.—Mr. J. P. Anderson has been appointed assistant engineering manager with Cammell Laird & Co. Limited, Birkenhead, in the place of Mr. W. H. McMenemey, who was made engineering manager a short time ago. Mr. Anderson was for some time with Scott's Shipbuilding & Engineering Co., Greenock, as assistant chief engine draughtsman, and left there about two years ago to take up the position of chief draughtsman at the engine works of Workman, Clark & Co., Belfast.

A NEW SHIP'S-SIDE SLIDING WINDOW WITH SAFETY SHUTTER.

Designed and Manufactured by J. Stone & Co. Ltd., Deptford, for Mr. Vanderbilt's M.Y. "Ara."

As distinct from the rectangular sliding windows which have now become a feature of many first-class passenger steamers, a new type of ship's-side sliding window has recently been brought to our notice. This window has been specially designed for use in close proximity to the water-line and, as will be readily understood, is of exceptionally heavy construction. The motor-driven yacht *Ara*, which is the largest



The new Ship's-Side Window, 27 in. by 30 in., as fitted in the Motor Yacht "Ara."

yacht of her kind in the world, and was built for Mr. W. K. Vanderbilt by Camper & Nicholson Limited, Southampton, was fitted with this type of window, as designed and manufactured by J. Stone & Co. Limited, of Deptford. The windows fitted in the *Ara* are of the clear light type and are of rectangular shape, 27 in. by 30 in., as illustrated above. As will be seen from this illustration, a heavy gunmetal shutter is fitted, and this shutter is arranged to slide vertically inside the window so that should the glass at any time be fractured, the admission of water is prevented by this shutter. A crank handle operates the window and the shutter through independent gearing. It is stated that the windows in the *Ara* are situated at a point nearer to the water-line than has ever been attempted in the case of any other ship with windows of this or similar type, and for this reason the glass was made of a thickness of 1 inch.

Southampton's Floating Dock.—The London & South Western Railway Company have placed an order with Sir W. G. Armstrong, Whitworth & Co., of Newcastle-on-Tyne, for the construction of a 60,000-ton floating dock to be moored at Southampton.

CAVITATION AND THE SPEED OF REAL SLIP.

Speeds of Real Slip—Influence of Real Slip on Propeller Thrust—Thrust Data on H.M.S. "Mackay" and U.S.S. "Pruitt."

In a paragraph touching on turbine propeller design on page 338 of our September issue it was remarked that the actual speed of the real slip at which the thrust of the propeller begins to fall off badly was in the neighbourhood of 16 ft. to 18 ft. per second.* It may be advisable to amplify this statement somewhat in view of the fact that much greater speeds have been used, as well as in order to make clear what is precisely the speed which is in question. If P = pitch of driving face of propeller blades in feet, and N = revolutions per second, V = speed of ship in feet per second, and W = forward velocity of following wake in feet per second, then $(P \times N) - (V - W)$ is the actual speed of the real slip in feet per second. Speed of screw in knots — speed of advance of screw in knots $\times \frac{101{\cdot}3}{60}$ gives the same result. Strictly, the "analysis" pitch or true pitch of the blade, and not the face pitch, should be used; this has the effect of slightly modifying the above figures.

Now, experience has shown very clearly that, although much higher speeds of real slip than 16 ft. to 18 ft. have often been used, when this approximate region is passed the screw commences to slip badly owing to cavitation appearing. The reason for this lies in the fact that the natural forces causing the water to flow into the propeller are the atmospheric pressure on the surface of the water, plus the weight of water per cubic foot and the immersion below the surface. At the surface the pressure is $14{\cdot}7 \times 144$ lbs. per sq. ft., and at 1 ft. immersion, 1 cubic foot of sea water weighing 64 lbs., it is

$$1 \times 64 + 14{\cdot}7 \times 144 = 2{,}181 \text{ lb. per sq. ft.}$$
$$= 15{\cdot}15 \text{ lb. per sq. in.}$$

If the thrust of the propeller at this immersion exceeds 15·2 lb. per sq. in., the water is unable to flow with sufficient rapidity to maintain contact with the blade, and a cavity will form between the blade and the water. But there is a great deal of air in sea water, and as soon as ever the tendency to the formation of a vacuum occurs the air commences to expand and cavitation gradually follows. This actually occurs long before a pressure of 15·2 lb. is reached; in fact, after a tension of about 6 lb. is created the expansion of these bubbles becomes very apparent in a laboratory test of sea water under an air pump.

The intensity of the thrust naturally varies very considerably over the blade surface with variation in blade shape, immersion, &c., and the region for the occurrence of the rupture can perhaps be better judged if the problem is stated in another manner. As the water flows towards the blade back its velocity increases and the pressure falls. The relationship between the two is given by $\frac{V^2}{2g} = \frac{P}{64}$, and at 1 ft. immersion, or P = 2,181 lb., the velocity of flow at which zero pressure occurs = 46·7 ft. per second. As long as the velocity is less than this the pressure is positive; if the velocity exceeds it the pressure becomes negative in value. But experience on trials has shown that this breakdown is likely to take place at a much lower speed of influx—that is, of real slip—than the theoretical value, and unless this speed be restricted to about 16 ft. to 18 ft. per second the propellers will commence slipping badly and will fail to produce increments of thrust for increments of torque, as they did before this point was reached.

That this influx velocity may be a better guide than that of a suggested limit of pressure per square inch of projected area is very clearly seen from a comparison of the performance of the only two vessels of which full thrust meter records are available. These are H.M.S. *Mackay* and the U.S.S. *Pruitt*.† In the following table the speeds of advance of *Mackay* differ slightly from those published by Mr. Holt, as the analysis from which these were taken involved a slightly different analysis pitch. The corresponding speeds of real slip in Mr. Holt's analysis average 18 ft. and 20 ft. per second. It will also be noticed that the *Pruitt* was working with a slight negative wake at full speed. If curves be plotted for the three trials, it is very clear that the *Mackay's* propellers had already broken down at 32 knots on the deep-load trial, whereas the *Pruitt's* were still capable of being driven harder before this tendency would be observed, and in the case of a sister ship fitted with direct-connected turbines the screws were actually driven to a much higher pressure on the blades before commencing to fail.

	H.M.S. *Mackay*.		U.S.S. *Pruitt*.
	Light load.	Deep load.	Standardisation trial.
Speed of ship	35·46	32·4	35·0
Speed of advance of screw	34·25	30·07	36·0
Revolutions per minute	353·4	334·6	442·5
,, second	5·89	5·578	7·375
Diameter × pitch of screw	10 ft. 6 in. × 12 ft. 6 in.	—	9 ft. 2 in. × 10 ft. 2 in.
P × N	73·75	69·8	75·0
V − W	57·9	50·8	60·8
Speed of real slip in feet per second	15·85	19·0	14·2
Recorded pressure per sq. in.—			
Projected area‡	13·38	15·03	15·66
Disc area‡	9·29	10·4	8·63
Tip speed of blades	12,300	11,720	12,700

‡ At actual immersion, *i.e.*, not corrected to 12 in.

In reciprocating engines the permissible limit of influx speed is distinctly lower. In the case of the well-known *Daring*, from the trials of which Mr. S. W. Barnaby first originated his pressure theory of cavitation, the final and satisfactory propellers, which gave 28·0 knots, had an influx speed of about 10·8 ft. per second. The set which failed at 24 knots had a real slip speed of nearly 18 ft. per second. In the case of several of the early direct-connected turbine vessels slip speed of even 24 ft. to 27 ft. per second were not uncommon, but the screw efficiency had already fallen considerably.

If the action of the screw produced a nearly perfect vacuum in these cavities between the blade and the water—that is, if sea water were a homogeneous fluid—then the falling off in efficiency would be slight; atmospheric pressure on the surface of the water would force in an adequate supply: but the fact that the cavities are filled with air, or water vapour, or other gases more or less, partially counteracts the atmospheric effect and leaves the mass of water flowing through the screw largely reduced in consequence. It is the presence of this air in sea water which so largely accounts for the reduction of the theoretical speed of influx to the screw to about one-third of this value in practice, and the

* On page 338 this speed was inadvertently given as "per minute" instead of "per second."

† *See* Trans. I.N.A., 1920, and Jour. Am. Soc., N.E., Feb., 1921.

(*Concluded on page* 450.)

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Oil-burning Installation of the "Majestic."

The *Majestic*, originally designed as the *Bismarc*, was not intended to burn oil fuel. When the vessel was taken over by the White Star Line the owners desired an oil installation to be fitted identical with that fitted in their vessel, the *Olympic*. The oil was, therefore, arranged to be carried in side bunkers on each side of the boiler room, in the fore cross bunker, and in the double bottom, and sufficient was carried for the double voyage, bunkering in New York. The usual settling and overflow tanks were provided, and special arrangements were adopted for the warming of the oil and the control of its temperature. The oil-pumping arrangements are illustrated by a number of very complete diagrams. In addition, the heating, measuring, steaming out, and fire protection installations are briefly described. In general the designs of the *Vaterland* and *Majestic* are more or less identical, but with the introduction of oil fuel in the latter the coal bunkers on "H" deck in the *Vaterland* have been done away with on the *Majestic*, and thus a considerable increase in passenger space secured.—*Ober-ingenieur Schätzle, Werft, Reederei, Hafen*, September 7, 1922, p. 551; 5 pp.; 9 ff.

Motor Tankers "Julius Schindler" and "Ossag."

This article contains very complete information on the design and construction of the new German oil tankers *Julius Schindler* and *Ossag*, recently completed by the Deutsche Werft, Hamburg, to the order of Julius Schindler and the Stern-Sonneborn oil companies, of Hamburg. The vessels, which are built on the ordinary transverse system of construction, have the following principal particulars:—Length b.p., 309 ft.; beam (moulded), 45·5 ft.; depth, 24 ft.; draught, 19·5 ft.; contract deadweight, 3,700 tons; displacement, 5,940 tons. The powering of the vessels was decided upon from the results of model experiments carried out at the Hamburg Tank. The main engine had to be a 1,550 i.h.p. Burmeister & Wain four-stroke and built by the A.E.G. The model experiments showed that a speed of 9·75 knots could be obtained for this power, and this speed was taken as the contract speed. Actually, on trial, a speed of 10·08 knots was obtained. The hull and engine weights (the latter including all auxiliaries) were 1,837 and 453 tons respectively. The engines, as usual, were fitted aft, the main machinery consisting of a six-cylinder installation, cylinder diameter 630 mm., stroke 960 mm., developing a brake horse-power of 1,160 at 125 r.p.m. The propulsive coefficient $\left(\frac{\text{E.H.P.}}{\text{S.H.P.}}\right)$ was 64 per cent.

Plans of general arrangement and midship section are given, and the engines are also completely described and illustrated. One interesting feature of the latter is the adoption of the Michell thrust block. The results of trials carried out by the A.E.G. being so successful, the Deutsche Werft propose to fit the Michel thrust block exclusively in future vessels. Particular attention was given to the design of the propeller shafting in order to eliminate torsional oscillation. It was found necessary to stiffen up the scantlings required by the Germanischer Lloyds, and on the trials this step was justified when the vibrations of the system were examined by the Geiger torsiograph. Many other interesting features of these vessels and their outfit are given.—*Schiffbau*, September 6, 13, 20, 1922; pp. 1,299, 1,327; 13 pp.; 16 ff.

Reinforced Concrete Decks in Insulated Holds.

When a hold and the 'tween decks above it have to be separately insulated the dividing deck requires to be insulated on both sides. This practice in the past has been unavoidably expensive, heavy and complicated. With the introduction of the Pohlmann "Thermos" system of insulation, in which a light non-conducting concrete, combined with air cases in which the air circulation is restricted, is used for covering the steel surfaces of the ship's holds, the idea naturally occurred to eliminate the steel dividing decks and substitute reinforced concrete decks instead. In this article the author describes several applications of the idea to vessels being built by the Bremer Vulkan and Deutsche Werft companies. The construction and erection of the deck is carefully detailed, and, incidentally, it may be mentioned that the complete approval of the Germanischer Lloyd has been obtained for the design. The constructional work and details, which are well illustrated, are interesting, but the most important part of the article is that dealing with the comparative costs of an ordinary, double-insulated steel deck and the reinforced concrete decks. The experience of the Bremer Vulkan and the Deutsche Werft both show that, with a convenient spacing of pillars, the concrete deck is slightly lighter than the steel, while the cost is almost exactly half. The system of construction is rapidly gaining favour, and is to be adopted in further vessels under construction at these yards and also in vessels being built by Messrs. Blohm & Voss and the Deutsche Werke, Kiel. The system has much to commend it from the point of view of first cost, upkeep and cleanliness, and is an interesting development in what may be called heterogeneous ship construction.—*R. Rudow, Werft, Reederei, Hafen*, September 22, 1922, p. 581; 3 pp.; 17 ff.

Flooding Calculations.

Flooding calculations are usually carried out in ship work for two purposes. First, to investigate whether the flooding of a hold will destroy a vessel's reserve buoyancy, and with this investigation the determination of consequent trim is included. Secondly, to investigate the initial stability in the damaged condition. Two distinct methods are available for the solution of this problem. First, what is known as the "lost buoyancy" method, in which the weight of the vessel is assumed constant, and, second, the "added weight" method, in which the weight of vessel is increased by the weight of the water entering the damaged compartment. In this article the author considers the flooding problem by both methods, and points out at each stage their related significance in a very interesting manner. He has apparently set himself the task of determining which method offered the greatest simplicity for practical manipulation, and finally states that, from the point of view of labour involved, it is immaterial which method is used. The article forms an interesting contribution to the literature of the subjects of "flooding" and stability in the damaged condition.—*M. Micalich, Schiffbau*, September 20, 27, 1922, p. 1,325, 1,345; 5 pp.; 9 ff.

Approximate Integration.

The rules for approximate integration, which are used in ship calculations, may be grouped into three distinct classes. First we have those which involve an equal subdivision of the base of the figure whose area is to be determined, but the multipliers of whose resulting ordinates are unequal. Into this class fall such rules as Simpson's first and second and Weddle's rule. Next, we have those which involve an unequal subdivision of the base, but whose ordinate multipliers are equal. This class embraces the Tchebycheff rules. Finally, we have the class in which both base subdivision and ordinate multipliers are unequal. This class contains the Gauss rules. The writer of the article considers that the possibilities of the Gauss rules have not been sufficiently realised by naval architects, and the majority of the article is devoted to the deduction of the Gauss rules for two, three or four ordinates. The rules are applied to determine the area of a mathematical figure, and while the application of Simpson's three-ordinate rule yields an accuracy of ·3 per cent., the Gauss two- and three-ordinate rules yield an accuracy of ·12 per cent. and ·064 per cent. respectibely. This increase of accuracy ought to admit of fewer ordinates being used with the Gauss rules, which would tend to make the rules comparable with the Simpson as far as labour is concerned. The Gauss rules were fully described in a paper by Mr. W. S. (now Sir Westcott) Abell, given before the Institution of Naval Architects in 1908.—*Dr. Bock, Werft, Reederei, Hafen*, September 7, 1922, p. 561; 1½ pp.; 7 ff.

Favourable and Unfavourable Displacements from a Resistance Standpoint.

This article forms an amplification of M. Doyère's contribution to Mr. Lovett's recent Institution of Naval Architect's paper on "Proportions and Block Coefficients of Merchant Ships." After outlining the usual theory of mechanical similitude and its application to ship resistance problems, M. Doyère gives some interesting data based upon model experiments for the cruiser *Danton*. In a diagram to a base of displacement the resistance in kilogrammes

is plotted for a range of speeds. This diagram possesses very interesting characteristics, for from it can be seen that, with increasing displacement and given speed, the wave-making resistance may be actually reduced. For instance, at a speed of 18 knots for the *Danton* the wave-making resistance remains constant (or actually diminish) over a range of displacement from 9,000 to 14,000 tons: at a speed of 19 knots from 12,000 to 25,000; at 20 knots from 18,000 to 30,000, and at 22 knots from 30,000 to 50,000. Of course, these phenomena generally only occur with fine vessels of high speed. A further diagram, showing the effect of varying the displacement-length ratio for a given speed over a range of displacement is given. This diagram also emphasises the existence of regions of favourable and unfavourable displacement. When frictional resistance is taken into account the absolute superiority of the optimum displacements is minimised, although, nevertheless, these particular regions still remain the most favourable. The practical significance of the investigation shows that the considerable caution should be attached to the Admiralty constant method of powering. With this method the percentage increase in power for a given speed is two-thirds the percentage increase in displacement. With the existence of favourable and unfavourable displacements the utility of the Admiralty constant is considerably reduced. The article forms an interesting contribution to this important branch of naval architecture.—*Charles Doyère, Bulletin Techn. du B.V.*, August, 1922, p. 177; 3 pp.; 3 ff.

A New System of Insulating Refrigerated Chambers.

The conventional methods adopted for the insulation of refrigerated holds, while generally successful, suffer from the disadvantage that decay odours, &c., sooner or later appear, thus necessitating renovation or, at times, complete renewal of the insulation. To avoid these defects a new type of insulation, formed of a light concrete, has recently been adopted in Germany. The concrete is, naturally, of a special composition, for ordinary concrete is not a good insulator. The conductivity of ordinary concrete in calories per square metre per metre thickness per hour is ·60. That of an ordinary brick wall is ·40, and for wood ·15. In addition, of course, ordinary concrete is heavy. The special concrete, formed of pumice stone and cinders, is much lighter, and has a conductibility of from ·20 to ·25. If one part cement is replaced by one part silicate (partly or wholly calcined) the conductivity reduces to between ·12 and ·18, *i.e.*, equal to that of wood. In order to admit of the cleaning of the holds, this concrete is faced with "Thermos" plaster. However, the feature of the new system is not so much the new material, but the disposition of the construction. In the case of an insulated barge recently constructed, the shell was first coated with Thermos cement and then air cases, composed of lath woodwork, and divided into narrow channels by cardboard divisions parallel to the ship's side, are fitted between the frames. These cases are in turn covered with Thermos cement and the whole surface flushed up. Only one hold was so fitted, the remaining holds being fitted out with the usual wood and charcoal insulation. The behaviour of the hold equalled in every way that of the ordinary holds. The air cases are one of the features of the system, and their design was decided upon after considerable research was carried out by the inventors, Herr Pohlmann, and Professor Knoblouch. Their research showed that air in motion was a much inferior insulator to still air, and as circulation is caused by difference of temperature between the outer (and, in the case of a ship, the hotter) and inner surfaces, this circulation is reduced to a minimum by subdividing the distance between the faces as mentioned above. The system has the advantage of being based upon scientific research and also of being very simple to construct. It has been approved by the Germanischer Lloyds, and since adopted in one form or another on the ex-German liners *Imperator*, *Vaterland* and *Bismarc*. In three former Hamburg-America liners the old and usual insulation has been replaced by the Thermos system. Altogether it has been fitted to about 30 completed vessels and to 50 in course of construction.—*Bulletin Tech. du B.V.*, August, 1922, p. 185; 2 pp.; 3 ff.

Oil Burning in Merchant Ships.

In a previous article the author has reviewed the development of oil-burning practice in German naval vessels, and in this article the parallel development of oil burning in merchant ships is considered. It is interesting to note, from the historical portion of the article, that oil was burnt in Russian vessels in the Black Sea as long ago as 1870. The influence of the development of the Russian and American oilfields is considered, after which the subject is treated in a technical and commercial manner. The relative economy of oil burning in passenger and merchant vessels is carefully considered. The main portion of the article deals with the development of such details of oil-burning installations as burners, filters, pumps and piping. The requirements of the classification societies are discussed and the safety regulations commented upon. As an appendix to the article, the recent literature of England, France America and Germany is briefly referred to, and a description of some 50 recent patents relating to oil burning adds to the utility of the article. The article contains considerable information on the subject and is worthy of reference.—*Marineoberbaurat Schulz, Werft, Reederei, Hafen*, September 22, 1922, p. 584; 9 pp.; 7 ff.

German Naval Experience with Directional Wireless.

In a long and comprehensive series of articles the author reviews the development, the German naval experience with, and the present possibilities of directional wireless. The early work of Hertz and Marconi, and the fundamental considerations of the subject, are carefully considered in the first portion of the article. In the second portion the land experience is very fully considered, special attention being devoted to the investigation of all possible sources of error, which are of overwhelming importance in the practical utility of the subject. These errors may be grouped into three classes: those peculiar to the instruments as such, those produced by geological conditions and disturbances, and those whose cause is unknown. Errors are generally greatest at nights, and they amount to as high as 10 deg. This portion of the article also deals with the application of directional wireless to aeroplanes. In the final portion the actual ship experience is reviewed, and the experience obtained on surface vessels, submarines and aircraft is carefully considered. The work, because of its length, is difficult to review in detail, but, as the treatment is so thorough, anyone interested in the subject will derive considerable information from its study. Many valuable references to important related works are included in the article.—*E. Bindseil, Werft, Reederei, Hafen*, January 7 and 22, February 7, and September 7, 1922, p. 5, 33, 68, 556; 17½ pp.; 36 ff.

Sound Isolation on Shipboard.

While much has been done in the way of improved means of heat insulation on shipboard, and especially in connection with the transport of foodstuffs, the amount of published experience on the insulation of sounds, noises, &c., is very scarce. However, the subject is by no means unimportant, particularly in high-class passenger work, where it is very desirable to eliminate the engine-room noises, deck-winch noises, and the drone of electromotors and artificial ventilation. These noises are divided into two clear classes, those which are propagated through the air and those which are propagated through the steel structure. The ordinary structural linings of rooms exclude a slight amount of noise, but in way of machinery special insulation linings should be fitted to exclude both heat and noise. With the introduction of wireless telegraphy on shipboard the necessity for efficient sound insulation was increased. About twenty years ago the subject was experimentally examined at the Royal Dockyard, at Kiel. Experiments were made on a steel box lined with various materials. A magnetically-vibrated tuning fork was fitted inside the box and intensity of external noises was optically registered by reflection from a specially constructed diaphragm connected to the box. The results showed that the insulative power increased very rapidly with increase in lining thickness for small thicknesses, but for thicknesses above ¼ in. very little improvement could be effected. The order of superiority was teak, asbestos, cork and felt. These experiments referred to air-propagated sound. A more complete set of experiments was carried out in 1912 to test the efficiency of the different materials and methods of insulation against structurally propagated noises. In this case the boxes were fitted up with a microphone and noises were produced by the ringing of a bell outside the box, striking the box with a pendulum, and by dropping an iron plate on to the box. Asbestos in direct and indirect contact with the sides of the box and direct cork and sand insulating media were respectively examined. The indirect contact asbestos was easily the most efficient of all systems. A further set of experiments was tried on the effect of artificially ventilating these insulated rooms. It was found that when the air was mechanically sucked out and drawn in naturally through ventilators fitted with dampers, the best results were obtained. The results of this research have been embodied in the construction of the wireless rooms on board German naval vessels. The author points out, however, that the advantages of indirect contact are evidently not appreciated in merchant ship applications and recommends its adoption.—*Dipl. Ing. Freudenthal, Werft, Reederei, Hafen*, August 7, 1922, p. 459; 5 pp.; 9 *ff.*

The Frictional Resistance of Ships.

The first portion of this article deals with the early work of W. and R. E. Froude and Tidemân, and consists of the usual presentation of the subject. Next the Reynolds or Rayleigh law is examined, the work of Dr. Stanton being largely drawn upon. From this examination a simple relation is set up, connecting the frictional resistances of similar models at the same speed, and which merely depends upon the fact that the sum of the length decremental exponent and the speed exponent should equal two, to conform to the Rayleigh law. The Froude experiments on varnish, paraffin, sand, &c., surfaces are then examined in the light of the Rayleigh law in a manner somewhat similar to that adopted by Mr. Baker in his 1915 North-East Coast Institution paper, very little agreement, however, being established from the comparison, owing, undoubtedly, to the smallness of the speed in the Froude experiments. The text portion of the article is devoted to the determination of the correct frictional and form resistance of models. The first method consists of analysing the resistance results of two similar models and by assuming a speed index or exponent for the frictional resistance, this resistance is obtained from the solution of a simultaneous equation. The method is partly identical with that proposed by Mr. E. V. Telfer in the *Marine Engineer and Naval Architect* for October, 1922, but, in addition, the method is extended to admit of the value of the speed exponent for the models, frictional resistance being determined directly from the experimental results of the two models. An example is given of the application of the method to data published by Professor Schütte on models of the *Kaiser Wilhelm der Grosse*, which were made to scales of one-forty-eighth and one-fortieth full size respectively. Owing, however, to the small difference in scale ratio, no practical confirmation of the method could be obtained. Finally, a second method is outlined, whereby, from the results of one model having different natures of surface, the frictional resistance and the speed may be obtained. The expressions set up, however, are extremely complicated, and it is probable that the errors introduced in the course of their solution make the method merely of academic interest. (*To be continued.*)—*W. Den Boer, Scheepsbouw en Scheepvaart*, September. October, 1922, pp. 161, 177; 12 pp.; 2 ff.

Shipbuilding Contracts.

The present upheaval of economic conditions in Germany has enormously complicated the task of the estimation of ship construction prices. In normal times the most reasonable form of contract is that which specifies a given sum. This encourages the builder to introduce every method which produces economy in the construction of the ship and thus promotes industrial efficiency. During the war the cost plus percentage system was made popular, but, once peace conditions returned, this was quickly discontinued, because the shipowner was not safeguarded against the inefficiency of the shipbuilder, who, with this system, had lost much of his incentive towards technical progress. With the return to the old form of contract and the present perturbation of the mark, shipbuilders stand to lose heavily on this system unless the shipowner is prepared to meet the increasing costs of construction. That he should do so is undoubtedly reasonable, but the precise manner in which he should and at the same time not encourage the inefficiency of the builder, whose risk is thereby greatly reduced, is a very disturbing problem. In this article the author considers that the basis of price estimation should be the customary one of material, wages and establishment charges. These should be just as carefully estimated as in normal times, and a definite delivery date should be also specified. At the time of the signing of the contract, basis sums for material, wages, establishment charges and profit should be decided upon, and upon this total sum the contract should be awarded. Once the particular firm is decided upon, the shipowner should agree to meet the increased cost of such material as cannot be immediately ordered or is not in stock at the time of the contract. The increase in the cost of labour can be taken in proportion to the relation of the basis wage at the time of the contract to the average wage over the period specified, the increment being met by the shipowner. The establishment charges and profit increase will be probably actually less than the wages increase, but, once reasonably assessed, should be met by the shipowner. The method certainly involves a considerable amount of work, but it will undoubtedly be an equitable one. The efficiency of the builder is encouraged, and the shipowner does not have to pay for any managerial slackness on the part of the builder.—*Dr. C. Commentz, Hansa*, September 9, p. 1,079; 6 pp.

RECENT PATENTS RELATING TO MARINE ENGINEERING.

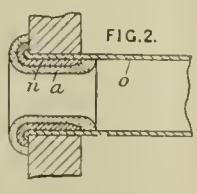
Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C

No. 183,479. Steam Generators, &c.

Lymn, A. H., 40, *Westminster Palace Gardens, Westminster. (Assignees of Springer, E.; Brünn, Czecho-Slovakia.) July* 20, 1922, *No.* 19,972. *Convention date, July* 20, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 123 (ii).]

Ferrules for protecting the ends of smoke tubes are made of refractory material, such as firebrick or fireclay. The exposed surfaces of the ferrules are preferably glazed. The ferrule *n* is moulded in position, a mould *a* being covered with plastic refractory material and forced into the end of a smoke tube *o*. The mould is burnt away by the furnace gases. The refractory material may contain salts forming a glaze when the ferrule is heated. The beading of the ferrule may taper so as to form a cutting edge in the direction of the draught.

FIG.2.



No. 183,481. Furnaces.

Akt.-Ges. Brown, Boveri & Cie., Baden, Switzerland. July 21, 1922, *No.* 20,057. *Convention date, July* 21, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 51 (i).]

In furnaces for steam boilers, superheaters or the like heated by liquid, gaseous or pulverulent fuel, the temperature of the furnace is reduced by supplying combustion products to the furnace in such a manner that the combustion of the fuel is not affected. In the furnace shown in Fig. 7, waste gases are supplied through a nozzle *a* surrounding a central nozzle for the supply of pulverulent or gaseous fuel. In the furnace shown in Fig. 8 combustion products are withdrawn by a fan *e* from the flue *d* and delivered to the furnace through slots *c* surrounding the fuel nozzle *a*.

FIG.7.

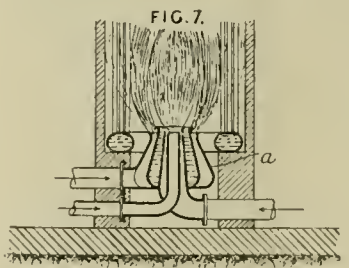
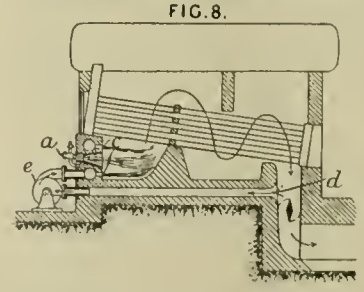


FIG.8.

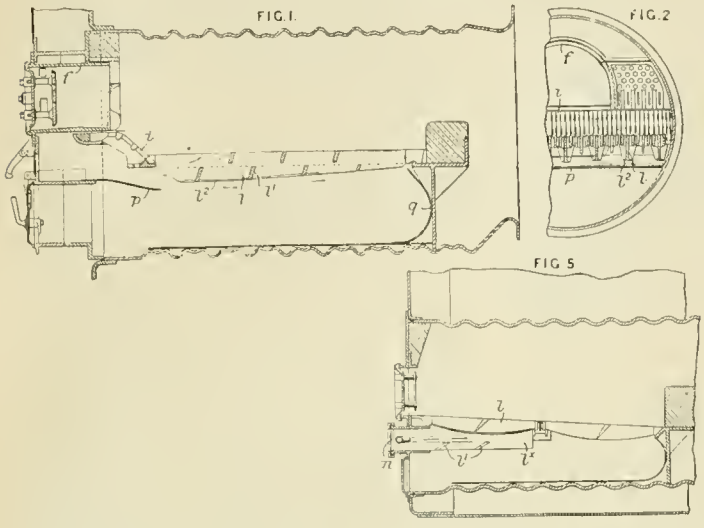


No. 183,508. Furnaces.

Reid, J., 4, *Lloyds Avenue, London. February* 24, 1921, *Nos.* 6,309 *and* 13,151. [*Class* 51 (i).]

Longitudinal partitions provided with upwardly and rearwardly-inclined ribs are arranged immediately beneath a furnace grate to form longitudinal air passages open at the bottom and covered at the top with shallow firebars. As shown in Figs. 1 and 2, the partitions may be constituted of deep firebars *l* having ribs l^1 and a strengthening flange l^2 at the bottom. These bars are preferably deepest at their forward ends and may be cast integrally with lateral shallow bars. The main grate is below the level of the firing opening *f* and is provided at the front with inclined bars *i*, as described in Specification 182,498. Air

from the hollow furnace front is directed by a plate p between the partitions and through the inclined grate bars i. Air entering the ashpit is directed at the rear of the ashpit upwardly towards the grate by a curved plate q attached to the ashpan or forming part of the bridge. In the modification shown in Fig. 5 partitions b,

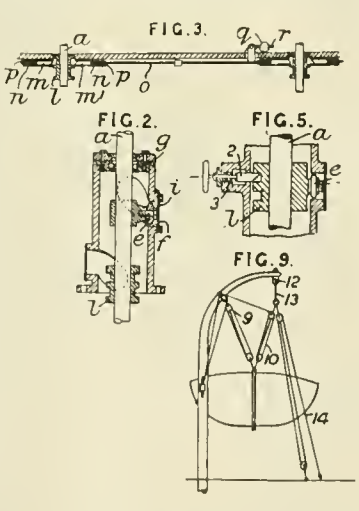


having ribs b^1, are arranged beneath the ordinary grate bars l to form passages opening at the front into a box or chamber n. Steam or air jets may be employed to increase the flow of air to the passages between the partitions.

No. 183,525. Boat Raising and Lowering Gear.

Ljungman, D. R., 9A, *Kungsgatan, and Jansson, F. D.*, 60, *Bangatan, both in Gothenburg, Sweden. March* 23, 1921, *No.* 9,030. [*Class* 115.]

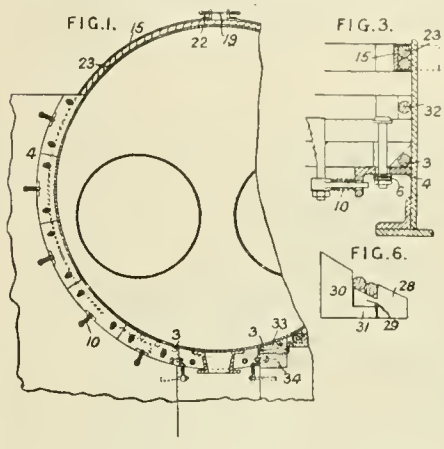
In vertically-moving davits a fitted with pulleys e adapted to glide on inclined paths f, and provided with stopping arrangements to prevent them from swinging in the wrong direction, the stopping gear comprises comb sleeves l attached to the davits and co-operating with locking bolts adapted to engage the comb by means of springs, and the davits are provided above and below the combs with ball or roller bearings which take up the lateral pressure and are capable of vertical movement. Fig. 3 shows one arrangement of stopping gear comprising locking bolts m, m^1, provided with springs n and bevelled as shown, the bolts engaging in pairs and being connected by arms to a rod o, which is operated longitudinally by a lever r having a counterweight g. Fig. 5 shows an arrangement wherein the comb sleeve l carries the pulley e, a separate bevelled locking bolt 2, provided with a spring 3 and capable of rotation on its own axis, being fitted to each davit. In modifications of this latter arrangement the grooves in the comb sleeve are vertical or at some other inclination. A projecting plate i is fitted to flanges provided on either side of the inclined path f. Fig. 9 shows an arrangement in which the swinging out of the boat under a heavy list is facilitated by the provision of an extra suspension tackle 9. When this tackle is not vertical the boat tackle 10 and the guy tackle 14 are fastened to a wire 13 suspended from the eye-bolt 12 of the davit. If the slueing of the davits is to be accomplished by the occupants of the lifeboat, the davit guys and suspension lines are fastened to cleats on the lower suspension blocks.



No. 183,532. Steam Generators.

Lord, J. L., Wellington Cement Works, Bury. April 15, 1921, *Nos.* 10,985 *and* 19,709. [*Class* 123 (ii).]

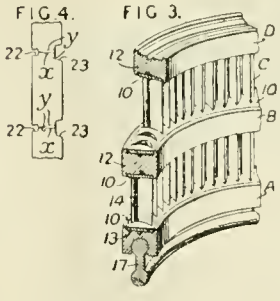
Settings; flues, external.—A gastight joint at the front end and around the blow-off valve chamber of a Lancashire or like boiler is formed by packing 3 (Figs. 1 and 3) in recesses formed by bevelling the brickwork, the packing being held on the recesses by plates 4, which are pressed against the packing by springs or spring washers 6, and against the boiler shell by springs 10. Additional packing 23 is held in steel bands 15 secured at their lower ends and pressed towards the boiler shell by springs 22 on a bolt 19 passing through brackets on their upper ends. A further packing 32 may be placed in recesses on the brickwork between the packings 3, 23. The packings 23 and 32 extend around top of the walls of the blow-off valve chamber. The two top courses nearest the flue walls are formed of bricks 28, 30 (Fig. 6), having engaging projections 29, 31, so that the packing 23 around the blow-off valve chamber may be readily inspected by removing the inner bricks 30. To obtain access to the packing 23 around the boiler shell, bricks 34, 33 are removed.



No. 183,691. Turbines, &c.

British Thomson-Houston Company Limited, 83, *Cannon Street, London.* (*General Electric Company, Schenectady, New York, U.S.A.*) *July* 6, 1921, *No.* 18,323. [*Class* 110 (iii).]

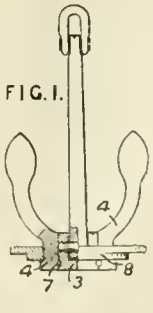
Blades.—Rotor blade rings of the kind described in Specification 11,918/07 are built up of blades 14 fitting into spaced notches in mounting rings 10, which are first fixed in grooves 13 in supporting rings 12, the rings and blades being united by fusion of metal, preferably by the method described in Specification 158,565. The rotor element A . . D is attached to the rotor by an expansion ring 17. The blades may flare from inlet to exit, in which case they are formed from strips of material (Fig. 4) by notching, as shown at 22, 23, and then cutting along the lines x, y in turn. The supporting rings are wedge-shaped. The invention is applicable to radial-flow turbines, and is particularly described in regard to radial-flow turbines having oppositely-revolving rotors with axially-extending interleaving blade rings.



No. 183,747. Anchors.

Clark, E. J., Stourdale, Heath Street, Stourbridge, Worcestershire. September 23, 1921, *No.* 25,227. *Addition to No.* 174,481. [*Class* 113 (i).]

Anchors described in the parent Specification comprise separate arms 4 pressed against a wing plate 8 by a centrally-disposed jointing block 3 in which the shank is swivelled. According to the present invention transversely-disposed aligned recesses in the contacting faces of the joint block and the arms receive bolts 7 to lock the parts of the anchor together. The joint block 3 also extends laterally beyond the edges of the arm 4.



No. 183,900. Turbines, &c.

Schmidt, F., 626, *West Ravenswood Avenue; Girard, E. L.*, 4064, *Broadway; and Messlein, M. A.*, 1201, *Washington Boulevard; all in Chicago, U.S.A. April* 12, 1921, *No.* 10,678. [*Class* 110 (iii).]

A jet-wheel turbine is actuated by products of combustion from exploding devices (Fig. 10), supplied with compressed mixture from a multi-cylindered compressor (Fig. 3), the devices having pressure-operated inlet and outlet valves. Steam may be induced

into the exploded gases before they reach the rotor. The compressor comprises four pairs of cylinders 24 . . 27, the piston rods 47, 48 of which are actuated through levers 57, a link 55 and a crank 52 from a power shaft, so that adjacent pairs, such as 24, 27, simultaneously compress charges drawn in from a carburettor through valves 28, 29. The charges are delivered through valves 33, 34 into pipes 31, 101, to one of four exploding devices 75 round the turbine casing. The mixture enters the device (Fig. 10) through a spring-pressed valve 99, and is exploded by a plug 94, which is

FIG 3.

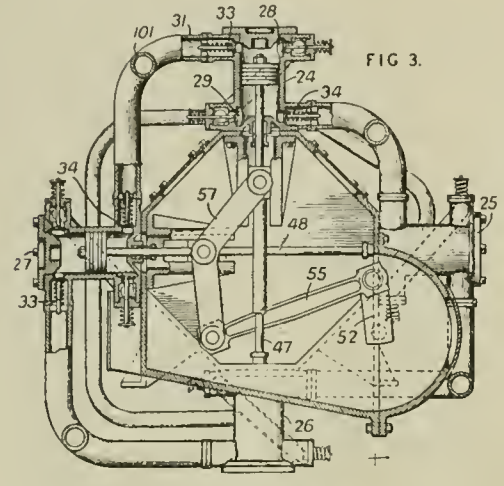
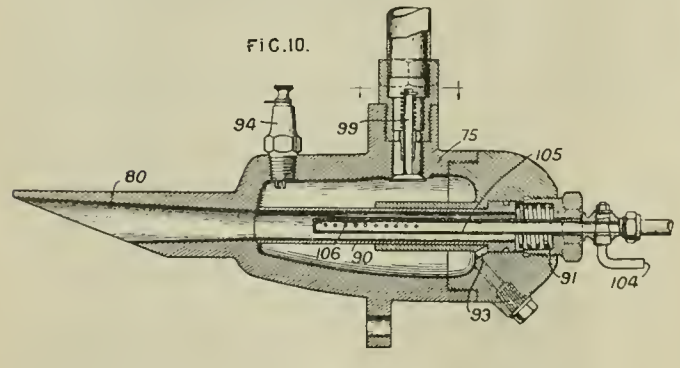


FIG.10.



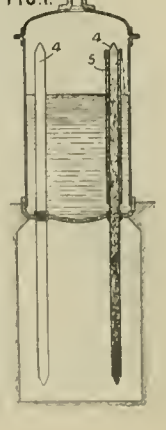
timed from the compressor. The pressure of the exploded gases acts through ducts 93 to shift a hollow piston 90 against a spring 91, so that the gases can escape into the nozzle 80. The velocity of the gases produces a vacuum effect within the piston 90, drawing water through holes 106 in a tube 105, which is controlled by a tap 104. The water is vaporised by the heat of the piston and mixes with the products of the next explosion when they leave the device. The mixed gases impinge tangentially on the rotor buckets.

No. 184,092. Steam Generators and Boilers.

Hooghuin, J. H., 655, *Prinsengracht, and Naamlooze Vennootschap Fabriek van Stoom-en Andere Werktuigen H. Jonker und Zoon*, 3E, *Groote Bikkersstraat, both in Amsterdam.* September 28, 1921, *No.* 25,713. [*Classes* 64 (i) *and* 123 (ii).]

A boiler for heating liquids and generating steam or vapour is provided with hermetically-sealed tubes 4 which contain a liquid and extend into the furnace and the water and vapour spaces of a boiler, and are surrounded by metal tubes or jackets 5 which are open at the bottom to the water space and at the top to the vapour pace.

FIG.1.

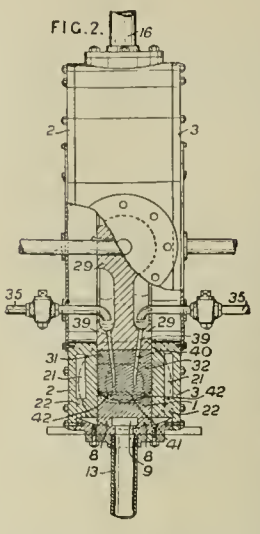


No. 184,879. Turbines, &c.

Howard, L. C. B., Transvaal Anthracite Colliery. Ermelo, Transvaal. May 20, 1921. *No.* 14,169. [*Class* 110 (iii).]

Jet-wheels; cooling and heating parts; blades, fixing. The turbine casing, consisting of a central annular portion 1 and circular side pieces 2, 3, is formed with annular cooling-water passages 9, 21, which connect between wells 8, 22, and

FIG.2.



have feed and exit pipes 13, 16. The rotor 29 and blades 32 dovetailed therein have cooling-water passages 39 . . 42, through which water fed from supply pipes 35 is circulated by centrifugal action. The pressure-fluid inlet port contains a nozzle and delivers the fluid tangentially to the blade surfaces. The turbine may be used with the power generator described in Specification 184,592.

No. 185,103. Turbines.

Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster.* (*Assignees of Herr, H. T., Brookway Lane, Merion, Pennsylvania, U.S.A.*) *August* 14, 1922, *No.* 22,105., *Convention date, August* 26, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

To increase the capacity of the low-pressure blading for handling large volumes of steam efficiently, the stator blades 17 are provided with partitions 18 dividing the elastic fluid into inner and outer portions, which are directed respectively on to reaction portions 22 and impulse portions 21 of a row of moving blades 20. The outer expanding passages between the partitioned stator blades 17 have a higher ratio of expansion than the inner passages, and expand the fluid to exhaust pressure. The impulse portions 21 of the blades 20 discharge at the tips into the exhaust chamber 16, while the reaction portions 22 discharge through stator blades 23 on to wide rotor blades 24 adapted to discharge at the tips, or at the tips and side, into the exhaust chamber. The member 25 supporting the blades 23 is adapted to prevent eddy losses due to intermixture of the exhaust fluid from the blades 21, 24. The blades 24 may be fitted with curved ribs 45. The impulse portions 21 are illustrated by Figs. 4 and 5, which show the inlet edge 45 at the side, the discharge edge 46 at the tip, ribs 48 fitting into cut-away portions 47, and a corner lug member 49 serving as a guide to prevent eddy losses. In a modification (Fig. 2) the fluid from the reaction portions 32 is again subdivided by partitioned stator blades 33 for direction on to impulse portion 35 and reaction portions 36 of a row of wide moving blades. In a further modification the rows 32, 33 (Fig. 2) are omitted. Specifications 14,053-15, 182,775 and 183,429 are referred to.

FIG.2.

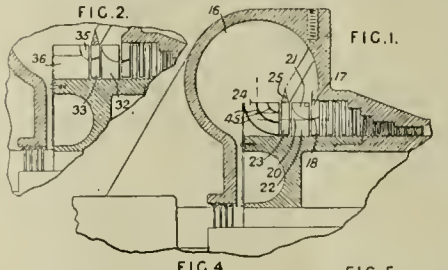


FIG.1.

FIG.4.

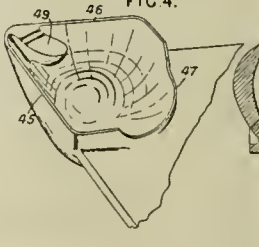
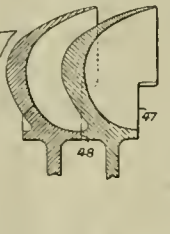


FIG 5



Cavitation.—(*Concluded from page* 445.)

accompanying table shows how speed and pressure vary with immersion :—

Feet immersion of Blade.	Pounds per sq. ft.	Pounds per sq. in.	Velocity in feet per second.
0	2,117	14·7	—
1	2,181	15·15	46·7
2	2,245	15·59	47·4
4	2,373	16·47	48·8
6	2,501	17·36	50·0
8	2,629	18·25	51·4
10	2,757	19·12	52·6
12	2,885	20·00	53·8
15	3,077	21·36	55·6
18	3,269	22·66	57·3
21	3,451	24·00	58·9
24	3,643	25·30	60·5
27	3,835	26·62	62·0
30	4,027	27·94	63·5
33	4,219	29·28	65·0

The Marine Engineer AND NAVAL ARCHITECT.

A Practical Journal for all Concerned in the Design Construction and Maintenance of

MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES — WELDING & MECHANICAL REPAIRS
AUXILIARIES & REFRIGERATION — CARGO HANDLING APPLIANCES

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

VOL. XLV. No. 543. DECEMBER, 1922.

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Mr. Robert Turnbull, who joined the old Union Line as a Seagoing Engineer 50 years ago, has passed away. Mr. Turnbull retired after the Union Line amalgamated with the Castle Line about 18 years ago.

Captain Robert Reynolds, late Marine Superintendent in London of the Union-Castle Line, died recently at Teignmouth. Captain Reynolds was appointed Marine Superintendent in 1913 and retired in 1920.

Owing to ill-health, Mr. J. Annan Bryce has retired from the position of chairman of Metropolitan-Vickers Electrical Company Limited, and his successor is Major-Gen. Sir Philip Arthur Manley Nash, who was chief locomotive engineer to the Great Northern Railway Company from 1897 to 1899, and afterwards was for 15 years in the service of the East Indian Railway. During the early part of the war he was Director of the National Filling Factories, under the Ministry of Munitions, and in 1916 became first Deputy Director-General, and later Director-General of Transportation to the British Forces in France.

Mr. C. E. Lloyd, Chairman of N. Hingley & Sons Limited, anchor and cable makers and colliery proprietors, Dudley, was returned as Unionist Member for Dudley.

Mr. Ronald M. Laird, C.B.E., of the firm of Cammell Laird & Co., shipbuilders, left gross estate of the value of £21,064, with net personalty of £18,692.

The death has occurred at Teddington of Mr. Charles V. Faviell, Chairman of John Stewart & Son (1912) Limited, ship-repairers, Blackwall and Poplar. Mr. Faviell was 57 years of age.

Mr. Ernest Darch, of Trinity Road, Wallasey, Cheshire, formerly of Hemans Street, Liverpool, for over 20 years in the service of the White Star Line, being latterly Chief Engineer of the ss. *Cretic*, left £2,076.

Mr. A. E. Battle has been appointed Engineer-Surveyor-in-Chief of the Commonwealth Navigation Service of Australia in succession to the late Mr. J. Fadden. Mr. Battle was for some time Superintending Engineer of the Southern Nigeria Marine.

Mr. W. J. Belsey, who has been Manager of the British Thomson-Houston Company Limited, Glasgow office, since 1905, has been transferred to the head office at Rugby as Manager of the Marine Department, and Mr. J. Miller has been appointed to succeed him as Manager of the Glasgow office.

The death took place recently at Larne of Mr. Hugh Wisnom, formerly Shore Superintendent of the Ulster Steamship Company Limited, Belfast. He joined the company as Chief Engineer in their first steamer, the *Bickley*, and succeeded the late Mr. R. N. Beith as Superintendent. On his retirement in 1920 he was appointed Consultant Engineer to the Company.

Mr. Norris R. Sibley, who has been in charge of the Westinghouse Electric & Manufacturing Company's Marine Department in New York for several years, has resigned to become New York District Manager for the London Steam Turbine Company, of Troy, N.Y. Mr. Sibley served as Assistant and Chief Engineer in several steamship lines, and assisted in compiling "The Blue Book of Facts," a book on marine engineering. After leaving the Army Transport Service, in 1918, Mr. Sibley became connected with the Westinghouse Electric & Manufacturing Company. He served as Guarantee Engineer on the ss. *Westwood* and the ss. *Agawam*, the first "fabricated" ship. He was also the Westinghouse representative at the plant of the Submarine Boat Corporation, where he supervised the installation of propelling equipment on vessels built at those yards.

Among the appointments for exclusive ship and engineer surveyors recently made by Lloyd's Register of Shipping are two engineers who had considerable experience with the United States Shipping Board. Mr. Leonard Peskett, Junr., son of Mr. Leonard Peskett, Naval Architect to the Cunard Steamship Company, has taken up duties at Newcastle. Mr. Peskett, Junr., served his apprenticeship in the engineering department of John Brown & Co., at Clydebank, and served during the war as Engineer-Lieutenant on H.M.S. *Campania* and H.M.S. *Powerful*. He secured his First-class Engineer's Ticket in 1908. After demobilisation he was appointed Assistant Superintending Engineer to the United States Shipping Board with headquarters in London. The second appointment is that of Mr. D. S. Whiteford, B.Sc., who has taken up duty on the Clyde. Mr. Whiteford served his apprenticeship with Caird & Co., Greenock, and took his Chief Engineer's Ticket during the war whilst serving in the Royal Naval Reserve. After demobilisation he returned to Glasgow, taking his Science Degree in Engineering in 1920. Mr. Whiteford was for some time Assistant Superintending Engineer to the United States Shipping Board, first at Glasgow and then at London headquarters, and subsequently joined the editorial staff of *The Marine Engineer* and *Shipbuilding and Shipping Record*, which he recently left to take up his new duties.

EDITORIAL.

MARINE REDUCTION GEARING.

IT is to be doubted whether any phase in the history of marine engineering progress has been productive of so much discussion, and that of a highly-controversial character, as has the application of reduction gearing to marine service. Many valuable contributions have been made on the subject to the Transactions of our Technical Institutions and to the Engineering Press, and these have undoubtedly shed considerable light on the elusive phenomena associated with this method of speed reduction. The view is, nevertheless, held in many quarters that a more frank disclosure of the difficulties experienced with double-reduction gears and the methods adopted towards their solution by individual contractors is highly desirable in the interests of progress. Failures in the case of several new vessels of large power have admittedly occurred comparatively recently, but it is not in the best interests of progress that undue prominence should be given to the unsuccessful aspects of the performance of such gears, as has certainly been done in several recent cases. Due regard should be had to the highly successful performances recorded by the majority of double-reduction gears, and it should be possible to concede this much without in any way dimming our intelligent appreciation of the fact that our knowledge of the phenomena embraced by reduction gearing is as yet incomplete, and that further experience, backed by intensive research, is necessary. Practical evidence of the determined efforts which have been made to sift the problems arising in the case of individual steamers is to be found in such contributions as those of the now famous paper by R. J. Walker and S. S. Cook, dealing with the *San Fernando*, and the later contributions of Dr. J. H. Smith and J. W. Wilkie, describing the difficulties experienced and the methods adopted towards their solution in the case of the double-reduction gears of the *Melmore Head*.

Considerable prominence has recently been given to the question of torsional vibrations as a possible cause of the difficulties associated with double-reduction gears, and while such a consideration cannot be ignored in any attempt at a solution, it is the opinion of many engineers to-day that, in more than one particular case, the possible effects of such vibrations have been unduly emphasised. With a view to arriving at an accurate appreciation of the magnitude and the character of these vibrations, Mr. A. T. Thorne, B.Sc., and Mr. J. Calderwood, M.Sc., have carried out important investigations on actual ships during the last two years, and in a joint paper read on November 17, before the North-East Coast Institution of Engineers and Shipbuilders, the authors gave some highly interesting particulars of the methods adopted and the results achieved up to the present time. Observations were made on several vessels fitted with double-reduction geared turbines, three of the vessels being twin-screw and five single-screw, and in the latter class was included an oil-tanker with machinery aft. It is pointed out that any elastic system will, in general, have a fundamental vibration involving only one node, and higher frequencies, involving a multiplicity of nodes, will occur up to an unlimited number. Methods are outlined by the authors which, in their application—if the mass of the shafts be neglected—are productive of a formula similar to that of Dr. Smith's. In the authors' view, however, the mass of the shafts cannot be neglected, and with Dr. Smith's conclusion that he has limited the critical frequencies in the modified *Melmore Head* arrangement to two, the authors are not in agreement, inasmuch as the mass of the shafts were not considered in that case.

Without entering into a detailed description of the apparatus used by the authors, it is interesting to review, briefly, the conclusions arrived at as a result of the observations made. It is considered essential in examining the vibrations arising from the propeller that the critical speeds, the actual variation in the resisting torque of the propeller, and the multiplying factor, due to resonance, should be known with a fair degree of accuracy. In all the cases examined by the authors the natural frequency of the systems, where it could be observed, was found to be within 1 per cent. or 2 per cent. of the calculated frequency, or that here, at least, practice and theory are in virtual agreement. With machinery amidships the damping effort is large and the multiplying factor small, while with machinery aft and a short stiff length of shafting, the damping is very much reduced, but the multiplying factor may become considerable. When resonance occurs at less than half-speed, tooth separation is regarded as improbable, so that in such case no unworkable range will occur. Tooth separation may, however, occur in the event of resonance at speeds in excess of half-speed, but in this case the unworkable range will be very small and the possibility of its coincidence with normal running speed can easily be avoided if the problem is considered during the design of the installation. Flexible shafts introduced between turbines and first-reduction pinions, and first-reduction wheels and second-reduction pinions appear to the authors to be the most satisfactory means of minimising the amplitude and effect of vibrations from tooth inequalities, and by these means they can be reduced to proportions from which no danger can arise, except in certain cases of coincidence with critical speeds. Cases such as the latter, it is suggested, can be avoided in the design of the gears.

In making public the results of these practical experiments, the authors have earned the thanks of the Institution and of the industry as a whole. As further experience becomes accumulated, and as the steel manufacturer, the gear cutter, and those responsible for the operation of the gears on service, contribute the results of their individual experience and observations, as we hope they will, there is reason to believe that we shall gradually overcome the shortcomings of this highly necessary adjunct of the steam turbine.

SHIPBUILDING PROGRESS.

AS a community dependent to a substantial extent for our livelihood on the shipbuilding, shipping and marine engineering industries, it behoves us—as it does every competitor in any branch of business—to study closely the progress of our rivals in these great industries. In the post-war period it cannot be gainsaid that this country has been confronted with greater competition from abroad than ever before, and this competition is to be found not merely in a spirited bid for the carriage of the world's merchandise, but also in everything associated with the construction of new tonnage and the repairs to tonnage already in operation. These are industries in which we had, in pre-war days, rightly regarded ourselves as supreme, but as a result of the war, and in no less part to the circumstances arising directly out of the war, other countries have greatly increased their capacity for the construction and repair of ships. In his presidential address to the Liverpool Engineering Society at the beginning of last month, Professor T. B. Abell, who occupies the chair of Naval Architecture at Liverpool University, drew attention to this increased foreign competition, and an intelligent recognition of the state of affairs shown should serve to stimulate all associated with these industries in this country to greater efforts, each in his own particular sphere.

A comparison between conditions existing at the end of 1921 and at the end of 1913 is productive of some very important figures. While this country launched, in 1921, a total tonnage of 25 per cent. less than in 1913, the same comparison in other countries shows that the increase in the United States was 350 per cent.; in Sweden, 250 per cent.; in Japan, 250 per cent.; in Spain, 150 per cent.; in Holland, 120 per cent. and

in Italy, 230 per cent. In the last two years, such have been the labour and economic conditions, we have witnessed the unpleasant spectacle of several fine vessels leaving shipbuilding and ship-repairing centres in this country, where actually acute unemployment existed in the industries concerned, to have their construction completed or repairs effected on the Continent. At the present time a heavily damaged vessel lies in one of our ports and tenders are being invited for pennant repairs from the principal United Kingdom and Continental contractors. The cost of these repairs has been estimated at, roughly, £15,000 by the owners' superintendent. In conversation with the owners the other day, the view was expressed, somewhat reluctantly, that it was extremely unlikely the repairs would be effected in the United Kingdom, as it was known that more than one Continental firm felt confident that, after allowing for the cost of temporary repairs sufficient for towage, they would be able to underbid British contractors.

Dealing with the question of ship design, Professor Abell discussed the effect of the progress in marine propelling machinery in the tonnage regulations. These regulations constitute, it was pointed out, practically the only State-regulated factor affecting ship design which has not been revised for many years, and, in indicating the possible trend of future propelling machinery arrangements, some interesting possibilities were outlined by Professor Abell. The progress of turbo-electric propulsion in America, and to a less but increasing extent in this country was discussed, and the President felt confident that the adoption of this form of propulsion would in the near future open up the question of a complete revision of the tonnage laws. In advancing this view, Professor Abell is influenced by the belief that the adoption of several small high-pressure turbo-generators, utilising superheated steam from small boilers, will eliminate the necessity for placing the ship's propelling machinery in the position usually known as the engine room to-day. The absence of a direct shaft connection between the steam engine and the propeller—the electric propelling motors would be situated right aft—would render it possible to accommodate the compact turbo-generators in the 'tween-decks or on the upper deck over the boiler room. The main condensers, presumably for convenience in the supply of circulating water, would be accommodated in the boiler room below. It is suggested that such an arrangement, combined with the absence of extended lengths of tunnel shafting, would effect marked economies not merely in floor space but also in cubic space, and would, moreover, result in a simplification of the ship's structure.

These and many other features discussed by Professor Abell have a very direct bearing in the shipbuilding and marine engineering industries, and as such are worthy the careful consideration of all concerned in these industries. A definite feeling exists to-day that the revision of the tonnage laws cannot much longer be delayed, and by such a revision the necessity for the building of an unnecessarily large vessel for a given carrying capacity should be eliminated.

DOUBLE-ACTING DIESEL ENGINES.

IT is a rather common fallacy to assume that the development of the marine Diesel engine lies in the direction of producing engines of larger power than are at present available. In engines where the two-stroke cycle is employed it is not a difficult matter to develop from 400 to 500 b.h.p. per cylinder, so that a single unit of six cylinders or two units of four cylinders each will furnish sufficient power for the propulsion of a cargo ship of average dimensions, and as has been frequently pointed out, such vessels, both numerically and from the point of view of aggregate tonnage, constitute by far the largest proportion of our mercantile marine. Hence, assuming that it could be demonstrated that higher powers than those mentioned above could not be obtained from a single Diesel cylinder, there would still be every inducement for designers to seek so to develop the Diesel engine that it shall ultimately be considered as superior to all its competitors, not only as regards efficiency, but also from the point of view of first cost and cost of upkeep and maintenance. In fact it has already been asserted that the problem of developing the high powered marine Diesel engine does not call for serious consideration since the cost of development is not justified in view of the fact that the number of vessels which could be fitted with such engines would be so small.

The question of increasing the power developed per cylinder is not, however, bound up with the question of producing units of larger powers, since even if the maximum power required remained the same it would still enable that power to be developed by the use of a smaller number of cylinders, thus tending towards a reduction in the weight and, therefore, in the initial cost of the engine. Further, any increase which can economically be made in the power developed per cylinder will also mean a reduction in the overall dimensions of the engine, and thus enable a reduction to be made in the size of the machinery space with a consequent increase in the cargo-carrying capacity of a vessel for a given size. It is these arguments which have led to the gradual introduction of the two-stroke cycle engine as compared with its rival operated on the four-stroke cycle, and it is the same arguments which suggest the use of the double-acting engine in which the cycle of operations is performed on both sides of the piston, thus leading to the doubling of the power developed per cylinder. So far, however, the double-acting Diesel engine has not made very great progress although the engine designed and constructed by the North British Diesel Engine Works Limited, an illustrated description of which appeared in our issue for September, represents a notable endeavour to solve the problem, and one which all British engineers are hoping will be crowned with success.

While, however, very few examples of double-acting Diesel engines can be given, the internal-combustion engine using gaseous fuel and working on the Otto cycle presents many examples of double-acting engines, thus indicating that the problems involved are capable of solution. Of course, it will be at once urged, the gas engine does not present such difficult problems as the heavy oil engine, since both the pressures and, therefore, the temperatures in the cylinder are far less in the former case than in the latter; but it can be argued that if the single-acting Diesel engine has been developed, following the lines laid down in the design of single-acting gas engines, so, too, if the difficulties experienced with double-acting gas engines are thoroughly understood, the finding of ways and means to eliminate these should point the way to the development of the double-acting Diesel engine. As an example of this, mention may be made of the piston rod and the cylinder cover with its gland and packing. In a very interesting paper, entitled "Working Practice in the Design of Large Double-Acting Two-Stroke Engines," read before the North-East Coast Institution of Engineers and Shipbuilders, Mr. A. E. L. Chorlton drew attention to the difficulty that has been experienced with the piston rods and the packings on large gas engines. These difficulties we might expect to be materially increased with the double-acting Diesel engine, and hence, as is exemplified by the North-British engine, they are eliminated. Other details of design could be mentioned which have been modified if not indeed substantially altered as the result of experience with other types of engines. Thus, in view of the success which has been experienced with double-acting gas engines, as indicated by Mr. Chorlton's paper, there appears to be no reason why successful designs of double-acting marine Diesel engines should not be gradually evolved.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT

Brief Reviews of Recent Publications.

Aluminium Repairing. By William H. H. Platt. London: Crosby, Lockwood & Son, Stationers' Hall Court. 5 in. × 7½ in. × ½ in. 70 + vii pages. Price 3s.

In this very brief work, the author has endeavoured to describe the tools and processes associated with the repairing of aluminium sheet and castings, and the joining of copper, brass and steel to aluminium. Several creditable isometric sketches illustrate the various methods of repair, and as the method of treatment, although not polished, is essentially practical, the book is likely to constitute a useful workshop auxiliary.

The British Cast Iron Research Association—Report upon Work carried out for the Members (Extracts from Bulletin No. 1). Central House, New Street, Birmingham, 1922.

In this report just issued by the Association, Mr. S. F. Fletcher, Acting Director of Research, has outlined the work undertaken by the Association on behalf of its members during the first half-year of its activities. The great need for increased knowledge in all things associated with cast-iron manufacture will be fully appreciated from the articles which have appeared in this journal, and the very fine work which the Association is undertaking in this connection renders it worthy the fullest support of British manufacturers. Without embarking on schemes of considerable expense the Association has used many of the problems submitted as furnishing data for extended research to be carried out as the financial resources may permit, and in this way, it is believed, the more immediate needs of the industry may be met.

Smithsonian Institution Annual Report, 1920. By Dr. Charles D. Walcott, Secretary. Washington Government Printing Office, 1922. 6 in. × 9¼ in. × 2⅛ in. 704 pages. Numerous Plates.

In 1846 the Smithsonian Institution was created by Act of Congress in accordance with the terms of the will of James Smithson, of England, who, in 1826 bequeathed his property to the United States of America "to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men." For the year covered by the report, the presiding officer *ex officio* was the then President Woodrow Wilson, and the Chancellor was the Lord Chief Justice of the United States. In presenting the report, the Secretary makes reference to the limited funds of the Institution and the augmented cost of its activities, but explains that despite these drawbacks it has been possible to advance knowledge. The results of the scientific work for the year ending June, 1920, are published in the volume, and these cover such divergent subjects as astronomy, meteorology, botany, insect and bird life, and racial history.

The Internal-Combustion Engine. Vol. I. By Harry R. Ricardo, B.A. London: Blackie & Son Limited, 50, Old Bailey. 6¾ in. × 10 in. × 1½ in. 488 pp. Price 30s. net.

The present volume deals more particularly with the development of the older form of slow and relatively heavy internal-combustion engine, and the author announces that the second volume, which will treat of the lighter high-speed petrol engine, will shortly be published. The book is divided into some 31 small chapters, only one of which deals specifically with marine Diesel engines, an arrangement, no doubt, in accordance with the author's expressed opinion that, "However great the progress in motor cars, in stationary engines, and in the marine engines of the internal-combustion type, it is in connection with air locomotives that the internal-combustion engine will probably play the most important *rôle*." Every important type of engine is described, including four-cycle, two-cycle, constant volume, Diesel cycle, gas, horizontal and vertical engines. A somewhat surprising feature is the absence of an index, and one of several omissions is the reference on page 51 to a plate which we have failed to trace. This work will prove a welcome addition to the available literature on the subject.

Steam Turbine Theory and Practice. By W. J. Kearton, A.M.Inst.N.A. London: Sir Isaac Pitman & Sons Limited, Parker Street, Kingsway, W.C.2. 5½ in. × 8½ in. × 1½ in. 456 + xvi pp. Numerous illustrations. Price 15s. net.

This work has been written primarily for the use of students and for designers, and free use has been made of the calculus throughout. A special feature, and one which is likely to appeal to engineering students and others desirous of probing the more advanced problems of theory and design, has reference to the excellent series of examples at the end of several chapters. Many of these examples have been worked out in full, and in all cases answers to the problems are given at the end of the book. In many works dealing with the same subject we have found a flagrant misuse of terms and symbols, some of which have been, in fact, inconsistent in themselves. The present author is to be complimented on having furnished as a preface a concise and intelligible epitome of the terms used throughout the book, and these will be found to be in accordance with the best modern practice. Chapter XVII, dealing with marine turbines and gears, is good as far as it goes, but it does not go far enough. Chapters IX and X, dealing with turbine rotor stresses, critical speeds, and the whirling of shafts, are likely to prove especially valuable to the student grappling with these complex problems, and the examples given will inspire confidence. Mr. Kearton has succeeded in presenting a valuable contribution to the literature on the subject.

TRADE PUBLICATIONS.

Modern Power Station Plant.—The English Electric Company Limited, of Queen's House, Kingsway, W.C.2, have recently issued their Publication, No. 388, dealing with the plant of a modern power station. This publication is a reprint of an article written by L. C. Kemp, B.Sc., A.M.Inst.C.E.

Marine Diesel Engines.—We have received from the Werkspoor Co., Amsterdam, a booklet illustrating and describing the various sizes and features in the construction of the Werkspoor-Diesel engine for marine purposes. A list of vessels already fitted with these engines is given, and actual illustrations of several ships are re-produced.

"English Electric" Turbo-Blowers.—We have received from the English Electric Co., Limited, Kingsway, London, a pamphlet detailing their standard turbo-blowers. The results of the tests of a blower of 37,500 cubic feet of free air per minute, at 15 lbs. per square inch, with a speed of 2,250 revolutions per minute, are given, which show that the efficiency curve is comparatively flat over a wide range of duty on either side of the normal. A second pamphlet describes the application of electric driving in Scottish Woollen Mills.

THE REVIVAL OF CAST IRON.—III.

By "EXAGGEROUS."

In previous articles it has been shown that, from the modern and scientific standpoint, very little work and study of great or vital importance has been directed towards the commercial emancipation of cast-iron. It cannot too often be said how necessary this work is to engineers and to engineering.

Exactly what the future has in store it would be impossible accurately to predict, but anyone with the most elementary knowledge or experience of our colossal ignorance about this material can be a true prophet in saying that developments are certain to come and some, at least, of them will be highly revolutionary. At the same time it is equally certain that these developments will be delayed so long as the average foundryman and engineer chooses to maintain the attitude of believing that science and scientific research are unnecessary things or that they can be conducted by any but efficiently trained and properly educated men.

The Chemist in Industry.

It is a comparatively common thing to find a large works or a large foundry with a laboratory staffed and equipped in such manner as to be a sheer insult to the word science, and an utterly unproductive outlay to the firm concerned. Quite frequently are such laboratories under the works manager or the foundry manager, the chemist doing what he is told or, if he is not told, doing little or nothing. Sometimes he will turn out dozens of analyses which are dealt with by some higher official, this apparently on the theory of keeping the laboratory busy.

Imagine a staff of medical students busily engaged in examining patients and reporting their findings to an estate agent; or imagine a number of juniors in a shipbuilding yard reporting to a chemist.

This state of affairs goes on all over the country, and of the total number of places having a laboratory this procedure is probably the one used in the majority. How silly, how hopeless it is, appears patent when written down, yet such are the solemn methods adopted by many clever engineers to the utter extinction of any material good that could, under other circumstances, be derived from the laboratory. The argument of these engineers is that the chemist is not a fit and proper person to deal with these matters, but they do not appear to grasp the fact that, if this is so, the only remedy is to get a proper chemist.

Underpaid Chemists.

Very many of the chemists employed upon iron foundry work are analysts of mediocre scientific education and are quite unable to hold their own against highly skilled engineers or experienced foundrymen. The result is that they simply do not try to do so and, if they are given the chance and take it, the result is frequently a terrible failure. At most foundrymen's meetings it is common talk about this chemist or that chemist who "shut up" a foundry and so forth, but rarely does anyone point out that the chemist in question was obviously not a chemist in the true sense of the term and that the trouble was simply an instance of a little knowledge being extremely dangerous. Much of the unpopularity of chemists in works to-day is due to the salary being poor and the results likewise. A chemist has to study three or four years at college and another three or more years in a works as a junior and yet another period as a senior assistant before he is fit to take on a chief's job. How then can one expect to get an efficient man at the average salary offered in the average works

The scientific brains of this country are not utilised, and the best of them have nowhere to go save into some academic post. During the war these people did astounding work, but it has never been publicly recorded, and never will. An individual man here and there is being given his chance and is trying to make progress by "solo efforts," but it will be long time yet before the manufacturers awake to the fact that team work, and team work only, will raise their industries to the level of those of the foreigner.

There is a story to the effect that a certain gear on our submarines gave endless trouble no matter what type of steel was employed and the authorities were nonplussed. A German boat was captured and to the great astonishment of our people it contained the same gear but made of special cast iron. Moreover, it gave satisfactory results in service, and was said to contain more sulphur than we, in this country, think proper to have in cast-iron. Thus do we fail to learn our lesson and wait until we capture a German submarine, or it captures us!

The Cupola.

Turning to a consideration of what is needed in order to bring our knowledge and our cast-iron up to scratch, the first point is, of course, the cupola. No time must be lost in trying to make this furnace more amenable to our requirements. The metal absorbs carbon and sulphur in an amazingly erratic manner, sometimes it will even lose carbon and sulphur—but we cannot properly control it, and the cupola has its own way with us. Tapping temperatures are another problem, and a big bit of research is needed in order clearly to indicate the means whereby we may always be able to obtain the greatest possible amount of superheat. Rate of melting presents another enigma and has profound effect upon the physical properties of the resultant casting just as much as has melting temperature. The questions of volume and pressure of blast and maintaining them together with a constant height of bed are things so mysterious and so baffling that at the moment we are in the hands of the providence which guides the habits of cupolas.

Moulding Practice.

The next problem is that of moulding practice, moulding sands and facings. Here, again, there is little useful knowledge available, and when we come on to casting metal which is necessarily hotter than ordinary metal or more sluggish than ordinary iron we find ourselves faced with the difficulty of knowing nothing beyond our previous practice, which is entirely rule-of-thumb. Everyone knows the British steel casting is prone to have a lot of holes below the surface; not all British castings, but too many of them; and it will be found that, as cast-iron progresses, the same trouble will occur with it as with steel. Even now, if you get a cast-iron casting which has to be machined all over, you will find the need for far more knowledge about moulding materials than we possess.

Another factor of which little is known is that governing the fluidity or viscosity of the molten metal. Anyone experienced in foundry practice is familiar with the particular phenomena which tell him that a certain ladleful of iron is "lively" or the reverse, yet nobody knows anything about the true reasons for this and how or why it occurs. Many pig-iron merchants make a big song about their particular brand of metal being specially good in these respects, but even they have no facts and figures and can give no explanation of it even supposing it to be true. The addition of ferro-silicon, of aluminium and so forth, will sometimes produce results which they will not do at other times. These points need

working out and must be elucidated before we can get sound castings from superior metal.

The precipitation of fine or of coarse graphite has been previously mentioned, and this, together with the amount of graphite precipitated, are points of the utmost importance about which, once again, we know little and can control less. Two irons of apparently similar analysis will be found to give different physical results, sometimes this will occur when different pig-irons have been used, but on the other hand, it has been known to happen when the same mixture of the same consignments is used. We have seen a casting here and there with graphite of wonderful fineness—like hairs even under considerable magnification—and beautiful distribution, but we do not know how it occurred and we have not seen the same makers reproduce it at will.

Elements in Combination.

The combined carbon, too, presents features as interesting as that in steel, but we call it pearlite or cementite in spite of the fact that it frequently possesses very different sizes and formations which must have a great effect upon the behaviour of the metal under practical conditions. No work exists to tell us anything about these points. The engineer or the foundryman has had cast-iron under his control for so long that it will take years to get it away from him, and many more to find out much about it.

The other elements usually present, such as silicon, sulphur, manganese and phosphorus, each play their part one against the other, or one with the other, but we know little about them and much the same old cast-iron is made in much the same old way in most foundries all over the country. It would seem as if Dr. Longmuir, the permanent director of the Cast Iron Research Association, has got a fine field to work upon—if we give him sufficient support and patriotism to enable him to do it in a large enough way. If most foundries had good laboratories and reliable records this work would speedily be done by reason of the mass of data that would be available. This is not so, however, and the data existing is largely unreliable or bristling with a number of varying factors which the people concerned had no knowledge of and no respect for.

Diesel Engine Demands.

The conductivity of the metal as regards heat would seem to be a vital matter in the case of internal-combustion engines, and the rate of this will undoubtedly vary according to the nature of the cast-iron. It is to be hoped that somebody will invent a simple apparatus for determining this quickly and easily in the course of works' practice. Which remark applies equally to an apparatus for determining the viscosity of the fluid metal.

Tensile testing seems to have fallen into discredit and more faith is placed upon the transverse test. While this may be correct, probably it is not. One cannot think that the transverse test will tell us all we need to know about the cast-iron of the future. Hardness tests, for instance, are highly essential, but Brinell and Shore tests on cast-iron are very inadequate and frequently inexplicable in their decisions.

Wear tests, under conditions of high temperature, will be most necessary, and a machine is needed to do this without a lot of previous preparation. Research work is a thing of great importance, but every-day laboratory work under practical conditions is of equal value, and we must have machines and apparatus which do not require a large and academic staff constantly to attend to them and to work out the results.

The effect of alloy-additions will come next, and we may expect to get cast-iron with "controlled" critical points. One result of this will be that qualities now only obtainable to a limited degree and in a haphazard fashion by the use of coldblast pig-irons, remelted irons, steel, and so forth, will be produced at will and according to requirements.

Conclusions.

It is greatly to be hoped also that these new improvements will come about and be attainable mainly by means of the cupola furnace rather than by any electric or open-hearth process. Our iron must be able to compete with steel and other metals in price as well as in quality; scientific workers should thoroughly absorb this fact, and whilst attempting to improve the quality should keep their eyes open to the cost of so doing. There is no need to despise the cupola because its control and its conditions are almost unknown and unexplored. It might be that the cupola was a furnace discovered during the war for all we know about it—but it has great possibilities and enormous flexibility.

Later on we shall get more work done on sands and facings. Materials will be discovered which allow gas to penetrate at will and metal not at all, moreover, these materials will be capable of being supervised from day to day by better tests than that of merely squeezing a handful. Ironfoundry practice is full of the unknown. There are immense areas where the foundryman and the engineer have feared to tread; there are other parts which have been trodden blindfold and are full of superstition and old wives' tales. Practically, nowhere is it properly understood and fully explained.

Let science be employed in quality and in quantity and the revival of cast-iron as the best and cheapest metal for the most modern engineering structures is assured beyond doubt.

STEAM TRAPS.

One of the most fertile sources of trouble in a steam engine, no matter whether it be of the rotary or the reciprocating type, is caused by the accumulation of water. This water may be formed in the engine itself by the condensation of the steam, a certain proportion of it is inevitably formed as a result of the expansion of the steam, but it is certain that a very large proportion of it is due to the water carried over with the steam from the boiler. The surest and also the best method of preventing the passage of water from the boiler to the engine is to employ superheated steam; but where the boilers are not fitted with superheaters, then other means have to be adopted. Among these one of the simplest is to install "steam traps" in the steam pipe lines. These traps—which are wrongly named, since according to the function they fulfil they should be called water traps—are in the nature of a baffle or series of baffles placed in the path of the steam so that the water accumulates upon the surface thus exposed, whence it drops by gravity into a vessel forming part of the trap.

The water drains either continually or when it reaches a certain level in the trap into the condenser. Thus these arrangements are entirely automatic and, provided they are periodically cleaned and adjusted, they will work without any trouble. The saving which results from their use, both as regards the greater economy of the engine and the far smaller risk of accident is, however, very considerable.

MACHINERY OF AUSTRALIAN COMMONWEALTH GOVERNMENT LINER "ESPERANCE BAY."

Details of Main Engines, Boilers and Auxiliary Machinery, and Notes on the Performance during the Maiden Voyages, London-Brisbane-London.

The Commonwealth Government liner *Esperance Bay* last month completed her maiden voyage, and it is proposed in this article to deal with some interesting features on the ship, and, generally, to describe several of the more important sections of the vessel's machinery and equipment on lines differing somewhat from the more or less stereotyped and monotonous descriptions which tend to invest all new vessels in a greater or a less degree with an inanimate sameness. Before proceeding on these lines, the following brief description of the vessel's more important characteristics will serve as a useful introduction.

The *Esperance Bay* is the second of two twin-screw passenger and cargo liners ordered by the Commonwealth Government Line from William Beardmore & Co., of Dalmuir, Glasgow, the first being the sister vessel *Largs Bay*, which ran trials about a year ago. Three additional sister vessels, namely, the *Hobson's Bay, Moreton Bay* and *Jervis Bay*, complete the group of five steamers of the Bay class and these last three ships were built by Vickers Limited at Barrow-in-Furness. All five vessels were built from the same plans and differ only in respect to a few minor sections of their auxiliary equipment. The principal dimensions of the vessel are as follows :—

Length between perpendiculars	530 ft.
Breadth, moulded	68 ft.
Depth, moulded, to shelter deck	43 ft. 6 in.
Draught	29 ft. 11½ in.
Gross tonnage	13,850.
Service speed, loaded	15 knots.

There are six decks and the hull is subdivided into 11 compartments by means of 10 watertight bulkheads. In general, the watertight subdivision of the vessel complies with the full requirements laid down by the International Convention on Safety of Life at Sea, and fireproof bulkheads are arranged in the superstructure, so that any outbreak of fire may be effectively isolated. The watertight-doors throughout are by Brunton Bros. Limited, and operate on the hydraulic system. Special bridge control, associated with an illuminated key plan of the vessel, is provided in the case of the watertight-door leading from the engine room to the boiler room and also in the case of the two after-tunnel watertight-doors. By means of this control, these three doors may be instantaneously closed from the bridge and are, in addition, provided with individual control at the door itself. A clear idea of the arrangement of these doors and their associated control gear may be gathered from the photograph which we show on page 462. The door shown is that leading from the engine room to the boiler room. It is situated on the centre line of the ship and the control gear may be seen on the left alongside a Graham loud-speaking telephone, which communicates with the bridge. The photograph on the same page, taken on the bridge, shows the key plan, and the position of the three doors may be clearly seen.

Propelling Machinery.

The main propelling machinery consists of two sets of Parsons compound turbines, constructed under licence at Dalmuir. These turbines drive twin screws through double-reduction gearing, the H.P. turbine rotating at 3,200 revolutions per minute, and the L.P. at 2,100 revolutions per minute, and, with gear reduction ratios of 35·5 and 23·1 respectively, the propeller speed is about 90 revolutions per minute. The total S.H.P. developed is about 9,000, which gives comfortably a loaded service speed of 15 knots ahead, and the astern power is approximately 70 per cent of that ahead. An excellent impression of the lay-out of these turbines and gears for one shaft may be had by reference to the *Marine Engineer and Naval Architect* for October, where, on page 379, we published a photograph of one of the sets for the *Jervis Bay*. The gearing, as may be seen, is of the interleaved type, the first-reduction wheels intermeshing between the two helices of the second-reduction wheel—an arrangement which makes for compactness. In the case of each shaft the propeller thrust is taken by a Michell single-collar thrust-block, and, in addition, Michell journal bearings are fitted to the turbines and gears. The illustration on page 460 shows, looking to starboard, the starboard main-gear case and the main Michell block-thrust These thrust-blocks, which are fitted with water-cooling pipes, ran throughout the maiden voyage without any necessity for such cooling. On page 459 we publish a photograph, taken from the middle grating, showing the complete starboard propelling unit, including H.P. and L.P. turbines on the left and main-gear case on the right. We show, on page 462, an illustration of the manœuvring controls for the port engine, and in the foreground may be seen the emergency valves associated with Aspinall's patent governor and forced-lubrication control, which is fitted to the main turbines. The bridge and engine-room telegraphs, direction indicators, &c., are by A. Robinson & Co. Limited, of Liverpool and Glasgow.

Boiler Room Equipment.

Steam is generated in three double-ended and two single-ended Scotch return-tube boilers, the double-ended boilers being provided with four furnaces at each end, and each single-ended boiler with a total of four furnaces. Smoke-tube superheaters of the Schmidt type are fitted in all boilers, and these are capable of superheating the steam by 200° Fahr. The boilers are oil-fired on the Wallsend-Howden system, the plant for which was manufactured by the Wallsend Slipway & Engineering Co. Limited. Pressure and transfer pumps are of the well-known Weir design and manufacture, and one of these pressure pumps may be seen in the lower section of the photograph on page 460, which shows the compact pumping and heating units. There are three of these standard units on board, two of which only are normally required, the third being held in reserve. In the same photograph, the "Foamite" fire extinguisher flasks may be seen on the left. Under the boilers, and extending across the ship, are the steam vapour spray pipes as required by the Board of Trade in the case of oil-burning vessels. All five boilers are accommodated in a single compartment arranged as a single and a double stokehold, the three double-ended boilers being accommodated abreast. A clear indication of the after-stokehold may be obtained from the photograph on page 459, looking to port, and the sand trays under each furnace can be readily seen. The main boilers are fitted with Diamond soot-blowers.

Refrigerating Characteristics.

Not the least interesting feature of the *Esperance Bay* is her refrigerating equipment, and we are able to publish with this issue some photographs taken in the interior of the brine and evaporator rooms situated on the port side of "D" deck. The refrigerating machinery consists of two large horizontal compound steam engines, each driving a double-acting CO_2 compressor. These engines, manufactured by J. & E. Hall, Ltd., Dartford, have cylinders 14 in. and 26 in. diameter by 21 in. stroke, and are of such capacity that, with all refrigerated

spaces filled, one unit is adequate. Mr. Harrow, the chief refrigerating engineer, states that even when passing through the Red Sea during the recent voyage it was only necessary to use one unit for 18 out of the 24 hours. We illustrate one of these large units on page 461, the two photographs showing respectively the crank and flywheel end and the compressor end. The compressor cylinder is drilled from a solid rectangular-section steel forging of enormous strength, as may be seen. In ships of this class, which are frequently called upon to transport heterogeneous cold cargoes requiring various degrees of temperature for their safe transport, special brine arrangements are necessary. On the *Esperance Bay* the brine distribution is arranged on the three-temperature system, by means of which brine for freezing or chilling and for thawing-out can be supplied independently to each brine-pipe section throughout the ship, and, consequently, to each refrigerated space independently of all others, according to the requirements of the cargo to be carried. On this her maiden voyage the *Esperance Bay* brought home a large consignment of frozen meat, including mutton, lamb and beef, in addition to an experimental cargo of oranges and eggs.

Fruit Cargoes.

In the carriage of chilled fruit, much that was hitherto unknown has now been added to the knowledge on this very interesting and important aspect of refrigeration, but there still remains further scope for research in this branch. Air ducts, fitted with louvres for controlling the admission and distribution of cold air for chilled fruit purposes, lead from four electrically-driven high speed Sirocco fans which are situated on "A" deck. These fans are driven at 600 r.p.m. by motors of 12 b.h.p., manufactured by the Lancashire Dynamo & Motor Company, of Trafford Park, and a complete unit is shown on page 462.

Some interest attaches to the photographs, which appear on page 461, taken in the brine room and evaporator room. These photographs show an interesting Arctic effect, but do not convey an adequate impression of the temperature conditions under which the photographs were taken. In the first of these, part of the brine-return trough and the individual return pipes with their frozen thermometers may be seen. The temperature of this compartment is normally —5° Fahr. and the brine delivery is of the order of —15° Fahr. In all, there are in this brine room 87 individual return pipes, while the total length of brine piping on the ship is given as approximately 4 miles. The second photograph shows the two large CO_2 evaporators, while the large pipe and embedded thermometer in the foreground show clearly the snow effect. A special feature of the *Esperance Bay*, as of her four sister vessels, is the large capacity for insulated cargo, the total volume of refrigerated space being approximately 370,000 cub. ft. Accommodation for frozen cargo is provided in Nos. 2, 3, 4 and 5 holds, and in "D" and "E" 'tween deck spaces. Nos. 1 and 6 holds and the 'tween deck spaces above on "D" and "E" decks are utilised for the carriage of general cargo. The insulation of the refrigerated compartments is effected by means of slabs of cork embedded in bitumen and faced with a magnesite compound. Effective resistance against vermin or damp, and complete air-tightness are some of the advantages claimed for this form of insulation.

General Equipment.

Special attention has been devoted to the cargo-handling appliances, and these are of a very complete nature. In all there are 23 winches provided. Of these, one 16-in. by 10-in. winch is installed aft for warping purposes only, and two 16-in. by 10-in. winches are installed on the forecastle deck for warping purposes and for working cargo, including the 35-ton derrick. Six of these winches are situate on the boat deck and are adapted to work the eight boat winches of the Mace type, which are also arranged on this deck. The boat davits are all of the "Australis" type, this pattern having been adopted after exhaustive tests had been made under the most exacting conditions. The steering gear, which is situated on "C" deck aft, is of the Vickers' electro-hydraulic type and is controlled by telemotor from the bridge. The telemotor gear is of the well-known Brown's type, the wheel and standard for which are shown in the photograph taken on the bridge and reproduced on page 462. Details of the passenger accommodation of these vessels have already been published, but it should be stated that special suites are provided for 12 first-class passengers and separate accommodation is arranged in two, four and six-berth cabins for 732 third-class passengers.

The main electric-generating plant comprises two large generators driven by compound steam engines and situated on a raised dynamo flat at the after-end of the engine room. These units, which are manufactured throughout by W. H. Allen, Sons & Co. Ltd., Bedford, are each of 125 kw. capacity, and are driven by a compound engine with cylinders 13½ in. and 19 in. diam. by 9 in. stroke, running at 400 r.p.m., and developing 182 b.h.p. We illustrate one of these units on page 460, and it should be noted, as will also be seen from the tachometer on the right, that this unit was running at 400 r.p.m. when the photograph was taken. The main switchboard which runs athwartship, is arranged on the same flat. In addition to the main electric-generating equipment described, a special emergency Diesel-driven Gardner set of 35 kw. capacity is provided on "A" deck.

The Voyage Described.

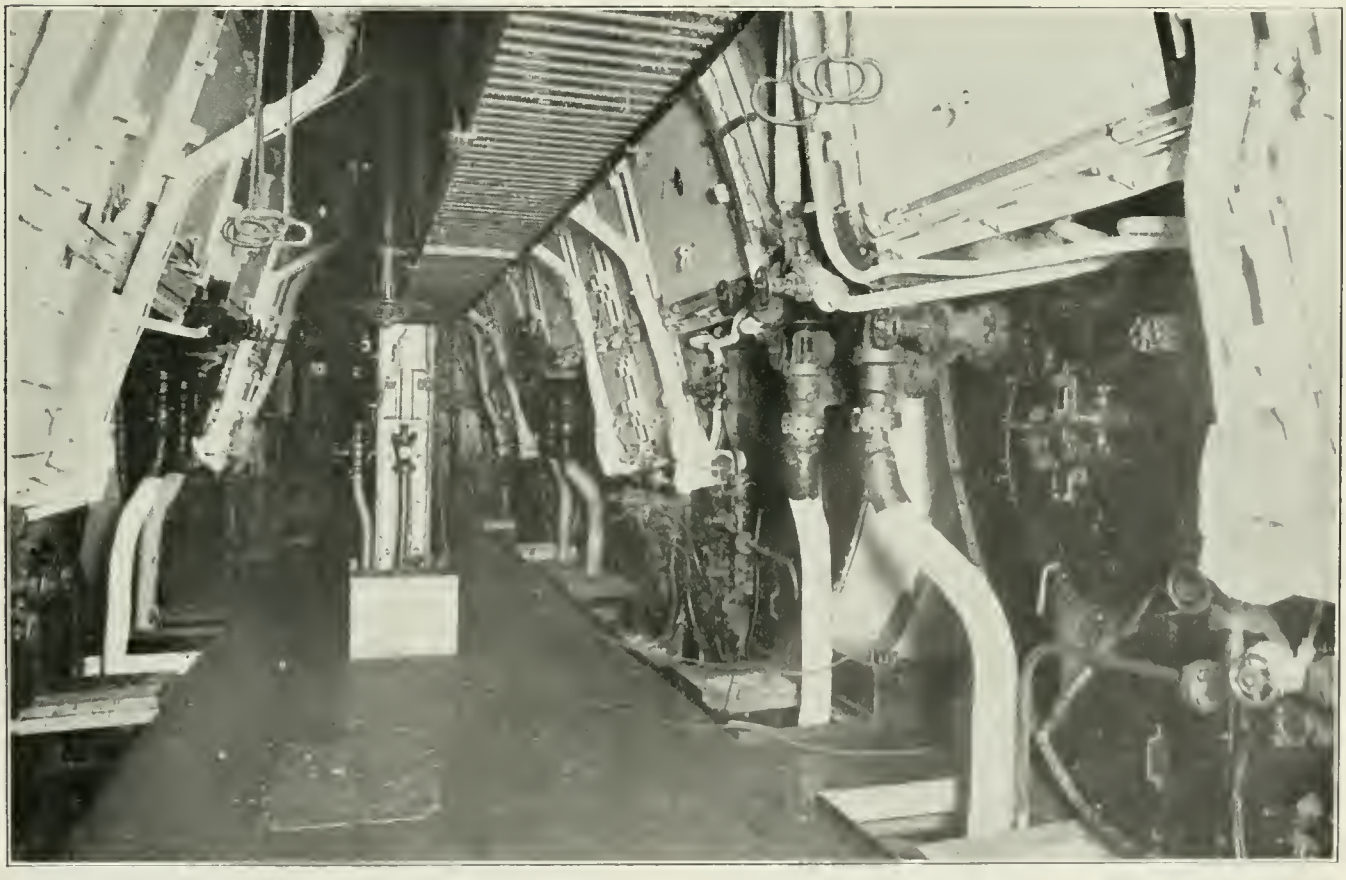
The five vessels of the Bay class are engaged on the recently inaugurated service between London and Fremantle, *via* the Suez Canal, a fast service by which Colombo is reached in 20 days and Fremantle in 30 days. The nature of this service requires that a service speed of 15 knots should be possible, and the shaft horse-power necessary is about 9,000. These conditions have been comfortably met by all the vessels of the class, and in this connection it is interesting to recall the trials of the first Beardmore ship, the *Largs Bay*. During her trials last December, in very heavy weather in the English Channel, a speed of 16·8 knots was attained at 92 r.p.m., and the power developed was 10,200 s.h.p. In her recently completed and highly successful maiden voyage no attempt was made by the *Esperance Bay* to attain maximum speed, but both on the outward and homeward trips the owners' schedule, drawn out and published months before, was adhered to comfortably and with almost perfect regularity, the vessel arriving at the various ports on both trips practically to the hour. We publish on page 463 a table setting out, for purposes of comparison, the actual dates of arrival at, and departure from, the various ports, and alongside these will be found the prearranged schedule dates.

These figures show the steady and regular running between ports. In the case of the outward voyage the schedule is only concerned with the date of departure from London, and thereafter the dates of arrival at the succeeding ports. On the homeward voyage, the schedule gives in every case the date of departure, with the exception of London, the terminal port, at which the date of arrival is prescribed. Taking the outward voyage dates it will be seen that only in the case of Colombo is there any discrepancy between the actual and schedule arrival dates, the vessel being a few hours ahead of time. On the homeward voyage the ship was a few hours late in departing from Fremantle, Colombo and Port Said, a discrepancy which was made up before London was reached, as the ship arrived at her last port true to time.

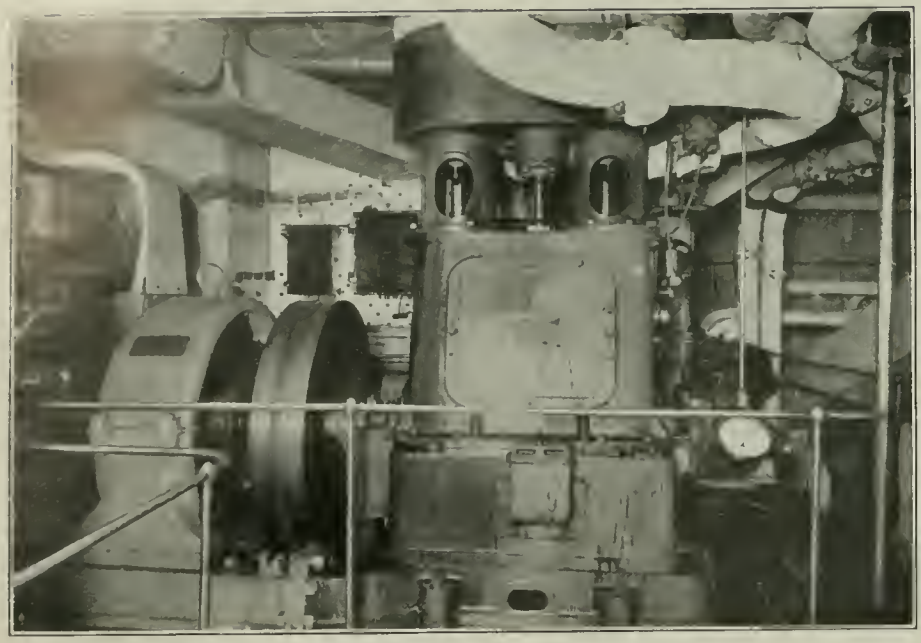
Performance Characteristics.

The average speed over the entire outward voyage works out at 14·5 knots, while that on the homeward voyage was 14·37 knots. In conversation with the chief engineer, Mr. A. U. Cross, it was ascertained that the performance of the main and

T.S.S. "Esperance Bay." The Main Engine Room, showing Starboard Turbine Casings and Gears.

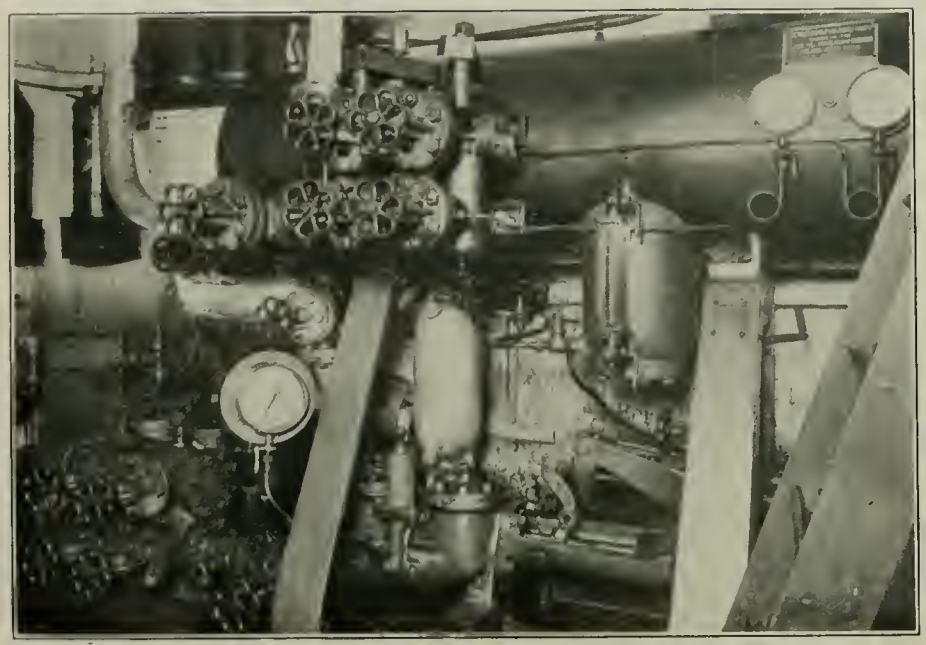


T.S.S. "Esperance Bay." After-Boiler Room, showing Furnace Fronts and Oil-Fuel Gear. (*See page* 457.)

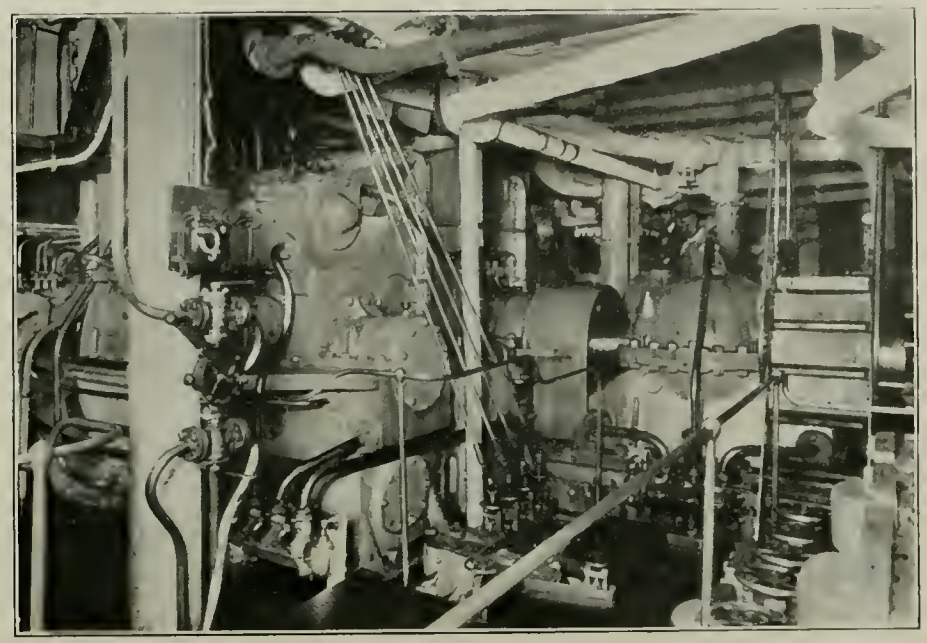


One of the Main 125 kw. Electric Generators.

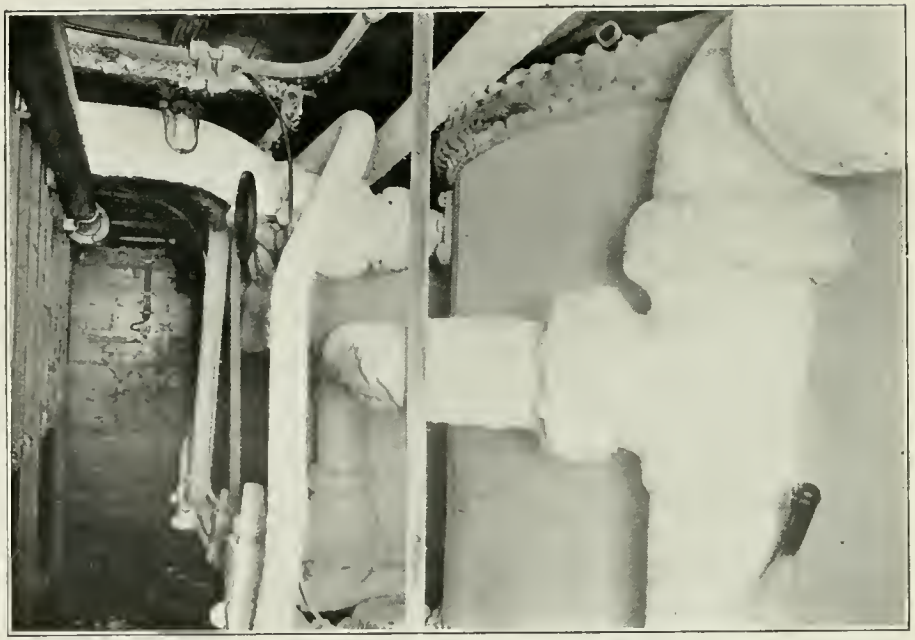
Main Switchboard on Dynamo Flat.



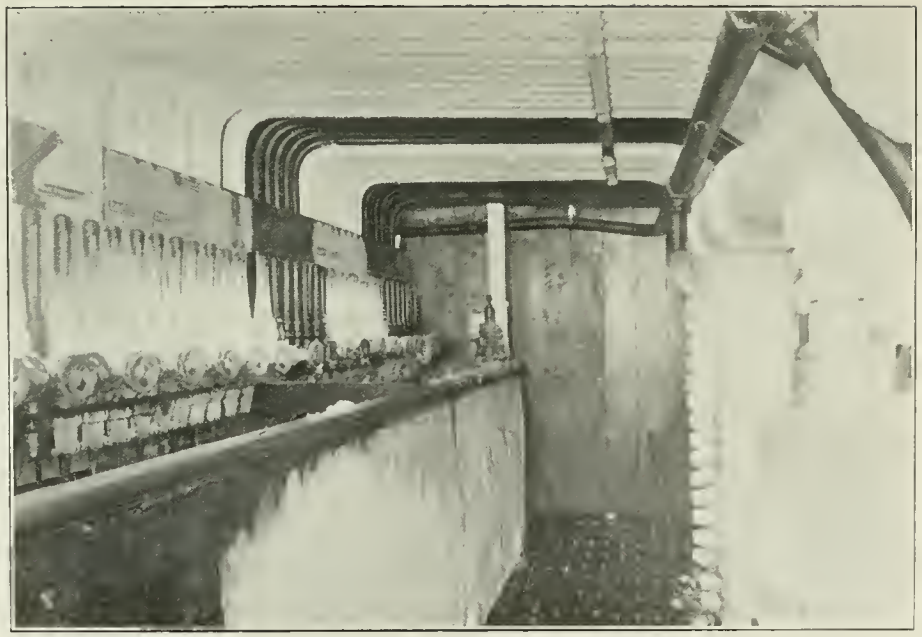
Wallsend-Howden Oil Fuel Heating and Pumping Unit.



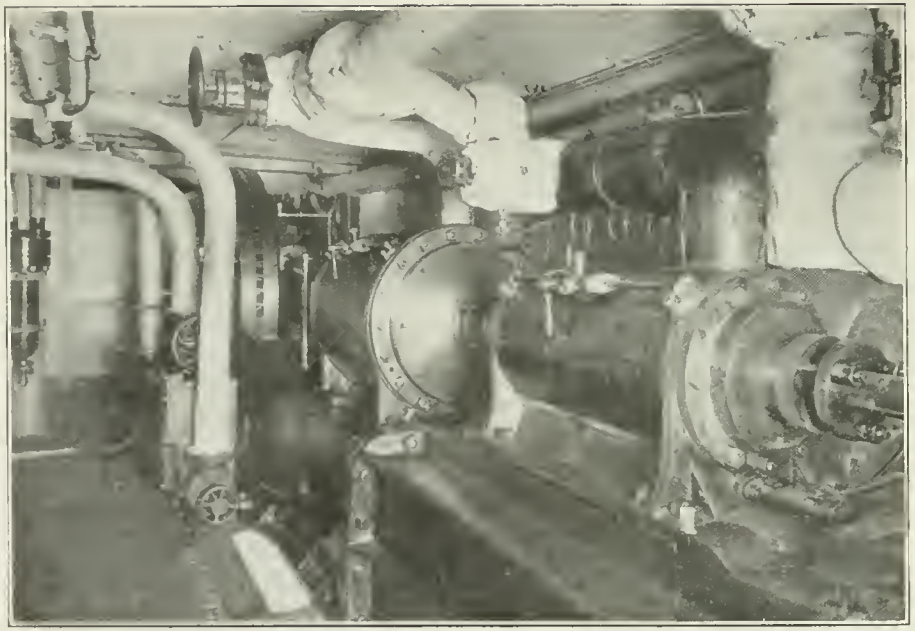
After End of Starboard Gears, showing Michell Single-Collar Thrust-Block.



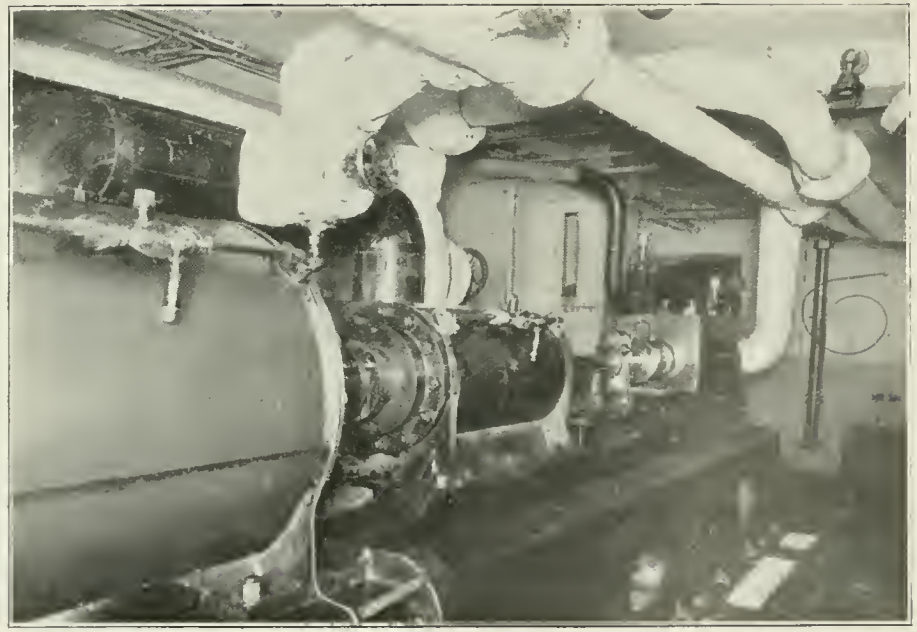
A View in the Evaporator Room, showing Main Evaporators.



The Brine Room, showing Brine Return Pipes.

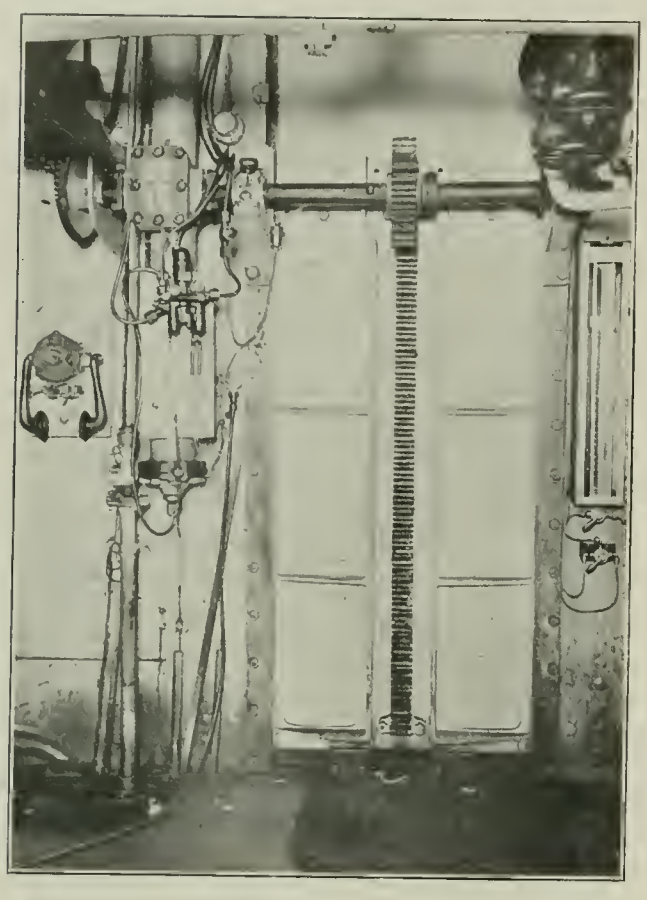


Hall's CO_2 Refrigerating Machine, showing Tandem Compound-Driving Engine.

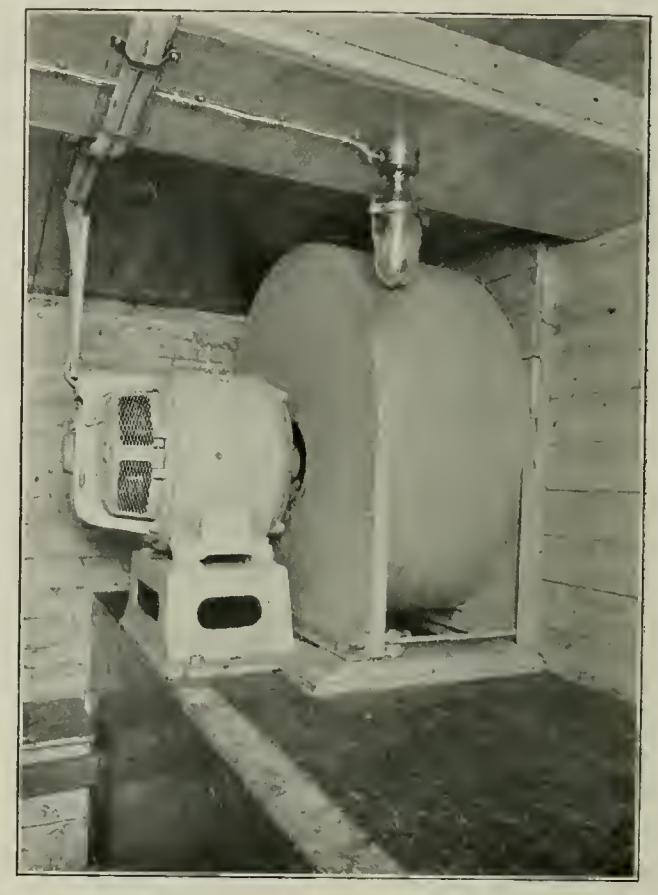


Hall's CO_2 Refrigerating Machine, looking towards CO_2 Compressor.

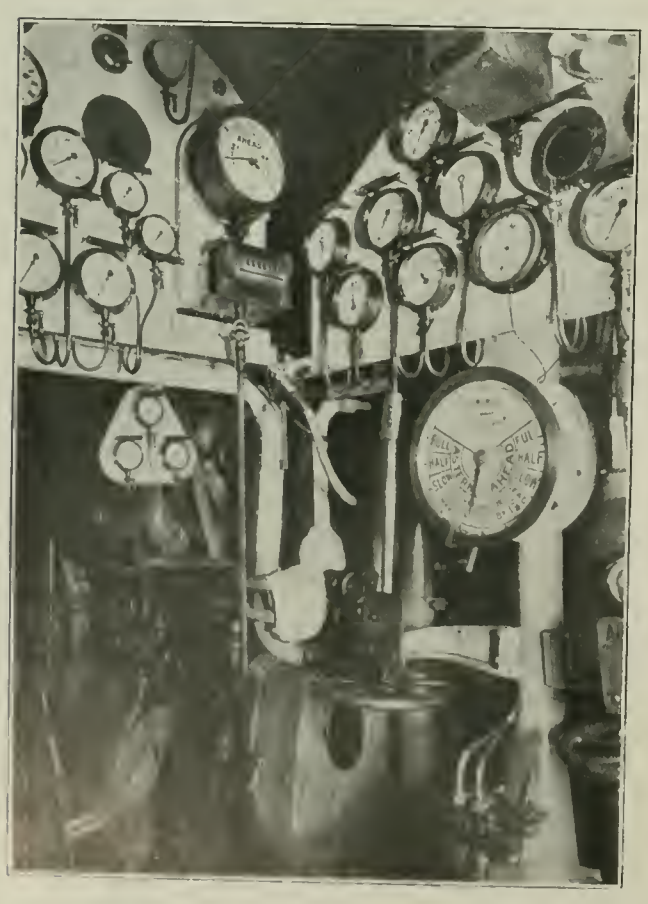
THE MACHINERY OF T.S.S. "ESPERANCE BAY."



Brunton's Watertight Door between Engine Room and Boiler Room.



Cold-Air Sirocco Fan on "A" Deck driven by 12 H.P. Motor.



Manœuvring Platform, showing Port Engine Control and Aspinall's Emergency Valves.

View of Navigating Bridge, showing Binnacle, Engine Room Telegraphs, &c.

auxiliary machinery and boilers had given him the highest satisfaction throughout the voyage, and no trouble of any kind had been experienced. An examination of his repair list gave ample confirmation of this as the items included thereon were solely ordinary running repairs such as might be comfortably effected by the ship's engineering *personnel*.

The running of the main turbines and double-reduction gears was characterised by a complete absence of vibration or objectionable noise, and during both voyages this feature was the subject of favourable comment among the passengers. Although a speed of fully 90 revolutions per minute was within the capacity of the engines, no necessity arose for a speed in excess of 86 r.p.m., the highest recorded on the voyage. The five boilers, already described, gave ample steam power even when a very heavy grade of oil fuel was taken on at Port Said. This fuel, which had a specific gravity of 0·94, was at first productive of heavy carbon deposit in the furnaces, but by an alteration in the size of the burners used and by maintaining the temperature at 230° Fahr. this deposit was eliminated and smokeless combustion was obtained. Under normal conditions the total fuel consumption for all purposes, including the large refrigerating demands, was of the order of 80 tons per day.

The total bunker capacity of the *Esperance Bay* is about 3,200 tons, and the stations at which fuel oil is taken during the voyage are those of Port Said, Colombo and Sydney. Two settling tanks are provided in the boiler-room wings, each tank having a capacity of about 80 tons or sufficient for roughly 24 hours' steaming. Pneumercator gauges, which register the depth and weight of oil in these tanks, are fitted at the forward end of the engine room in the vicinity of the manœuvring platform, as shown on the right of the photograph on page 462. Heating coils are provided in the two settling tanks and also in the other storage tanks, but at no time during the maiden voyage was it necessary to utilise these heating coils.

Including the refrigerating engineers, there are, in all, 14 engineers on board, the majority of whom are from the Clyde district, some having been previously associated with the builders, Beardmore & Co. at Dalmuir, while Mr. Cross, the chief engineer, stood by the *Largs Bay* and his present ship when both were building at Dalmuir. During our sojourn on board we could not fail to observe the excellent spirit of harmony existing in a very marked degree among all ranks of the engineering *personnel*, from the chief downwards, and to this fact, as also to the fine work of the builders, is to be attributed much of the success of the maiden voyage of the *Esperance Bay*.

In conclusion we desire to record our thanks to Mr. H. G. B. Larkin, General Manager of the Commonwealth Government Line, for the facilities placed at our disposal for photographing the vessel's machinery and equipment, and to Mr. J. H. Key, Assistant Superintending Engineer, Mr. A. U. Cross, Chief Engineer, and others, for their helpful co-operation.

Log of Maiden Voyage of T.S.S. "Esperance Bay" London–Brisbane–London.

Outward Voyage.					Return Voyage.				
Arrival Date.		Port.	Departure Date.		Arrival Date.		Port.	Departure Date.	
Actual.	Schedule.		Actual.	Schedule.	Actual.	Schedule.		Actual.	Schedule.
—	—	London	Aug. 1	Aug. 1	—	—	Brisbane	Sept. 23	Sept. 23
Aug. 11	Aug. 11	Port Said	Aug. 11	—	Sept. 24	—	Sydney	Sept. 30	Sept. 30
Aug. 21	Aug. 22	Colombo	Aug. 22	—	Oct. 2	—	Melbourne	Oct. 4	Oct. 4
Sept. 1	Sept. 1	Fremantle	Sept. 1	—	Oct. 6	—	Adelaide	Oct. 7	Oct. 7.
Sept. 5	Sept. 5	Adelaide	Sept. 5	—	Oct. 12	—	Fremantle	Oct. 13	Oct. 12.
Sept. 7	Sept. 7	Melbourne	Sept. 9	—	Oct. 21	—	Colombo	Oct. 22	Oct. 21.
Sept. 11	Sept. 11	Sydney	Sept. 16	—	Nov. 1	—	Port Said	Nov.2	Nov. 1
Sept. 18	Sept. 18	Brisbane	—	—	Nov. 11	Nov. 11	London	—	—

STANDARD TAIL SHAFTS.

Of the many valuable reports issued by the British Engineering Standards Association none should prove of greater value to marine engineers and shipbuilders than that dealing with tail shafts.* This report has been prepared by the sub-committee on ship machinery details and in a foreword, signed by Mr. A. E. Seaton, the Chairman, in dealing with the general principles underlying the policy of standardisation, says that the Association has endeavoured to keep three points in mind, viz., maintenance, first-cost and efficiency, its main object being not so much to set up an ideal as to co-ordinate as far as possible the best practice followed by marine engine builders generally. With regard to the particular problem of tail shafts, the standardisation of the length of the stern tube presented some difficulty owing to the fact that the shipbuilders differed in the methods of spacing the frames at the after end of the vessel, and therefore engineers could only vary the length of the stern tube accordingly. The shipbuilders have, however, unanimously agreed to vary their practice in order to facilitate the work of the engine builders by so placing the aftermost peak bulkhead as to suit the standard length of stern tube, the frames from that point to be in accordance with the rules of the registration societies.

Standard dimensions have been prepared for all sizes of shafts from 6 in. diam., increasing by ¼ in. up to 16 in. diam., and thence by ½ in. up to 20 in. diam., and for all these it is arranged that there shall be only 13 standard lengths of tail shaft, these varying from 8ft. 2 in. for the smaller sizes up to 19 ft. 3 in. for the largest sizes. The other dimensions, both for the shaft itself and also for the bushes and the glands, are tabulated and empirical formulæ are given, showing how the standard dimensions are obtained. Particular attention is paid to the taper portion upon which the propeller is keyed, and a special table is included giving dimensions of the standard key and key-way for all diameters of shaft. A table is also included giving standard dimensions for flange couplings for the intermediate shafts between the thrust and the tail shaft. This booklet should be in the hands of all who are concerned with the design and construction of cargo ships.

* British Standard Specification for Shafting for Marine Purposes. Published for the British Engineering Standards Association by Crosby, Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill, London, E.C.4. Price 1s. net.

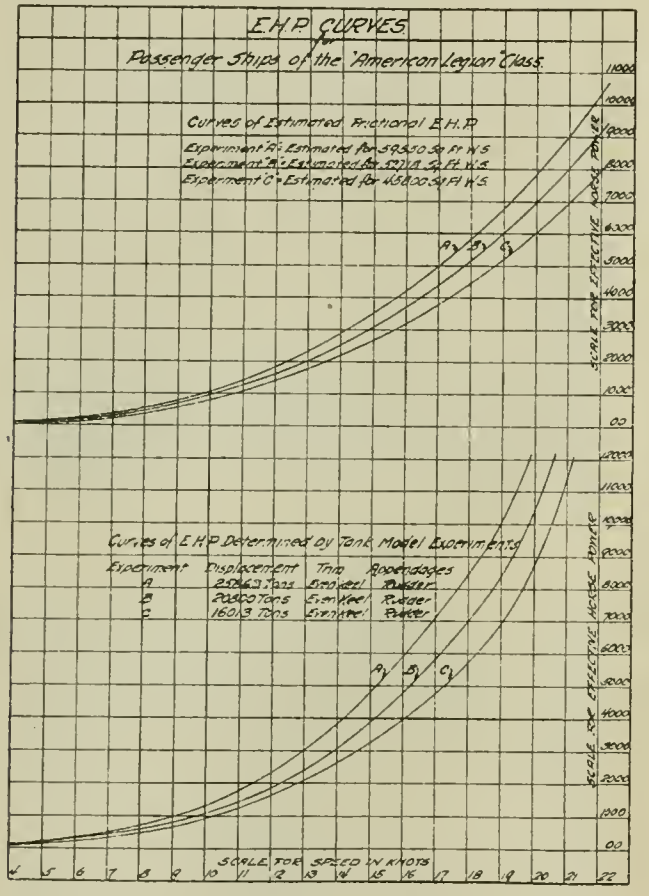
MACHINERY AND TRIALS OF THE PASSENGER SHIPS OF THE AMERICAN LEGION CLASS.*

With some Interesting Data of the performance of the "President Pierce."

When Mr. Rigg read his paper on "The Design and Construction of Passenger Ships," at a previous meeting, it was suggested that there should be a paper on "The Machinery of the Passenger Ships, American Legion Class," and this paper is, therefore, offered for the consideration of the members of the Society in the hope that it will be found interesting from the added circumstance that for these ships we have the results of a model with rudder pulled in the tank at Washington, D.C., a self-propelled model run in the same tank, and a fairly good standardisation trial of the completed ship at a draught corresponding to one of those at which the models were tested. The principal dimensions are as follows :—

Length overall	535 ft.
Length between perpendiculars	518 ft.
Breadth, moulded	72 ft.
Depth to shade deck	50 ft.
Designed load draught from base line	30 ft.
Corresponding displacement	20,980 tons
Trial draught	24 ft.
Trial displacement	16,013 tons
B. coefficient on 24-ft. draught	0·604
Coefficient of M. S. on 24-ft. draught	0·985
Prismatic coefficient	0·615
Wetted surface	45,800 sq. ft.

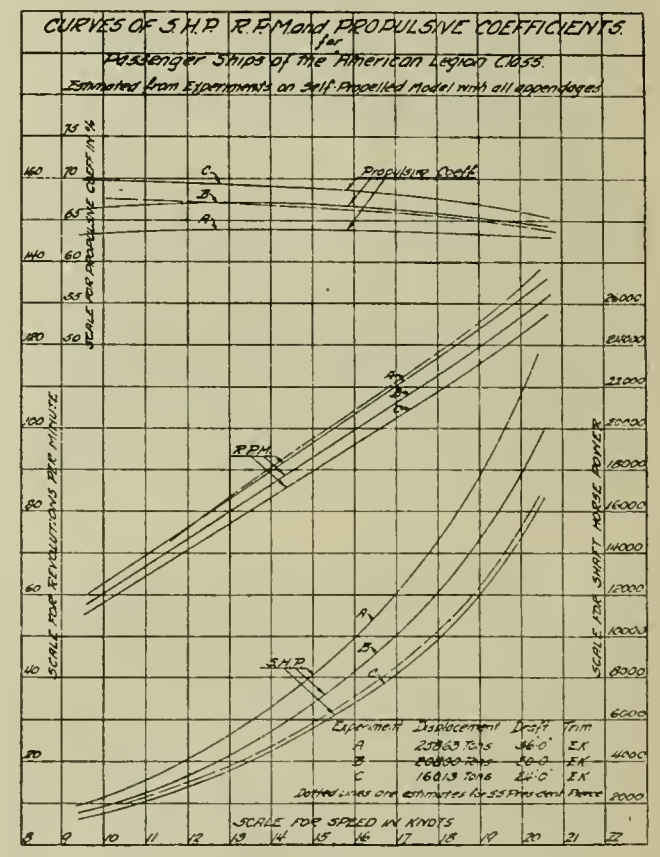
* Abstract of Paper read by Mr. Robert Warriner, before the Society of Naval Architects and Marine Engineers, in New York, November, 1922.



Curves of Effective Horse-Power.

Mr. Rigg has already given a considerable amount of information in regard to these ships in his paper (Transactions of the Society of Naval Architects and Marine Engineers, 1921), so that it is only necessary in this paper to give those particulars which have a direct bearing on the propulsion of the ships.

These vessels are of the shelter-deck type, with straight stem and cruiser stern. The framing is constructed on the longitudinal system, except at the bossing and at the ends. The shell plating is arranged with in and out strakes, with overlap butts below the water line.



Curves of Shaft Horse-Power, &c.

The two propeller shafts are supported by cast-steel spectacle frames in two pieces, bolted together at the centre line of the vessel, and the framing and plating of the ship are bossed out from where the stern tube intersects the hull proper to the point where it attaches to the spectacle frame. The keel is of the flat type and the rudder balanced, with double steel plates over cast-steel frame. The propellers are located with their centres 10 ft. 9 in. forward of the rudder axis. Bilge keels are fitted at the turn of the bilge and extend along the ship for a distance of 190 ft. They are 15 in. deep with double angles at the shell and stiffened at outer edge with a half oval.

The vessels of this size and type were constructed in three different shipyards, two by the Newport News Shipbuilding and Dry Dock Company, nine by the New York Shipbuilding

RESULTS FROM TRIALS OF S.S. PRESIDENT PIERCE

ECONOMY TRIALS

ENGINE ROOM.

Speed in Knots	Propeller R.P.M. Stbd	Propeller R.P.M. Port	Shaft Horse Power Stbd	Shaft Horse Power Port	Steam Circulation Stbd Turbine Lbs. per hour	Steam Circulation Stbd Turbine Lbs. per S.H.P.	Pressures Main Steam	Pressures Auxiliary Steam	Pressures Auxiliary Exhaust	Pressures Main Feed Pump Discharge
18	125.2	124.6	4525	4518	44895	10.70	249.1	243.8	16.5	333.9
16.8	111.6	110.0	4050	4030	35584	11.82	250.2	247.8	15.8	305.0
15.4	102.1	101.3	3447	3420	31502	11.89	252.2	244.8	10.4	333.8
	103.5	102.9	4715	4640	38949	27.4	251.0	244.9	4.7	
	96.0	90.0	2710	2500						

Starboard Turbine Pressures Hotwell	Starboard Turbine Pressures H.P. Exhaust	Starboard Turbine Pressures L.P. Inlet	Starboard Turbine Pressures L.P. Exhaust	Starboard Turbine Pressures Exhaust (ins. Hg.)	Starboard Turbine Temperature H.P. Exhaust	Starboard Turbine Temperature Exhaust	Starboard Turbine Lubricating Oil Discharge Temp. Fwd. M.T. Bearing	Starboard Turbine Lubricating Oil Discharge Temp. Aft M.T. Bearing	Starboard Turbine Lubricating Oil Discharge Temp. Fwd. L.P. Bearing	Starboard Turbine Lubricating Oil Discharge Temp. Aft L.P. Bearing
					12 Hour Full Power Trial					
14	296.8	79.9	47.1	28.3	100.5	98.7	118.8	130.0	102.3	115.7
					6 Hour ¾ Power Trial					
11	246.3	76.0	30	28.8	402.0	91.3	111.9	106.4	102.2	113.8
					6 Hour ½ Power Trial					
8	218.6	57.0	47	28.8	401.4	88.4	110.6	122.0	100.4	109.0
					Auxiliary Steam Consumption Trial					
	247.0	65.7	26	28.9	402.0					
					Full Power Backing Trial					

Auxiliary Pressures Starboard Cyl. Water Pump Discharge	Starboard Lub. Oil to Bearings	Starboard Lub. Oil to Coolers	Starboard Steam to Blowers	Port Cyl. Water Pump Discharge	Port Lub. Oil to Bearings	Port Lub. Oil to Coolers	Port Steam to Blowers
54	210	131	250.5	57	196	135	270.9
49	202	135	244.9	59	182	135	270.5
50	184	135	270.0	30.4	62.6	42.5	36.4

Temperatures Starboard Main Thrust Bearing	Temperatures Starboard Main Thrust Bearing Discharge	Temperatures Starboard Condenser	Temperatures Port Main Thrust Bearing	Temperatures Port Main Thrust Bearing Discharge	Temperatures Port Condenser	Temperatures Feed to Filters Temp.	Temperatures Room	Pump Strokes D.S.R.M. Lub. Oil Pump Starboard	Pump Strokes D.S.R.M. Lub. Oil Pump Port	Pump Strokes D.S.R.M. Main Feed Pump Forward	Pump Strokes D.S.R.M. Main Feed Pump Aft
41.8	66.2	38.6	44.9	70.3	69.0	14.5	74.7	25.8	24.1	16.4	6.5
40.2	67.1	39.1	40.3	72.1	65.1	12.3	75.0	25.2	22.3	13.6	7.7
36.4	62.6	42.5	36.4	69.3	50.5	11.8	73.4	24.3	22.5	0	14.5

FORWARD BOILER ROOM

No. of Boilers in Use	Air Pressure "W.G.	Steam Pressure No. 1 Boiler	Steam Pressure No. 2 Boiler	Steam Pressure No. 3 Boiler	Steam Pressure No. 4 Boiler	Steam Temperature No. 1 Boiler	Steam Temperature No. 2 Boiler	Steam Temperature No. 3 Boiler	Steam Temperature No. 4 Boiler	Size of Burners
4	2.5	265.7	264.9	264.9	261.0	444.0	443.3	443.8	443.3	3/32"
4	2.9	265.0	262.8	259.8	259.4	453.9	452.2	449.3	449.3	3/32"
4	3.0	262.4	261.3	258.0	262.1	451.3	451.3	451.3	451.3	3/32"

No. of Burners in Use No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Fuel Oil Pressure No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Temperature Fuel Oil in Burners	Temperature of Room
40	48	49	30	234.0	235.2	234.9	233.6	180.5	167
39	39	41	40	211.1	211.7	208.2	213.3	170.8	166.6
29	38	41	34	200.0	210.6	208.1	208.8	171.5	168.3

AFT BOILER ROOM

No. of Boilers	Air Pressure "W.G.	Steam Pressure No. 5 Boiler	Steam Pressure No. 6 Boiler	Steam Pressure No. 7 Boiler	Steam Temperature No. 5 Boiler	Steam Temperature No. 6 Boiler	Steam Temperature No. 7 Boiler	Steam Temperature No. 8 Boiler	Size of Burners
4	2.5	260.7	260.4	260.4	438.6	438.6	448.4	442.4	3/32"
4	2.9	259.6	255.7	259.8	439.5	441.1	444.7	445.0	3/32"
4	3.0	258.8	259.9	260.1	437.9	436.3	442.5	439.0	3/32"

No. of Burners in Use No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Fuel Oil Pressure No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Temperature Fuel Oil in Burners	Temperature of Room
50	50	50	50	227.2	218.7	220.0	226.3	185.8	183.7
39	42	42	41	207.1	204.4	204.9	207.7	176.2	173.7
29	30	29	30	205.6	207.5	205.6	211.3	186.9	183.8

FLATS AND GRATINGS

Temperatures Fr. Heaters	Temperatures Aft Machinery Flat	Temperatures Dynamo Platform Fwd.	Temperatures Dynamo Platform Aft	Generator Output Volts	Refrigerating Plant Amperes Forward	Refrigerating Plant Amperes Aft	Refrigerating Plant Temperatures Lge. Mach. Cond. Inl.	Refrigerating Plant Temperatures Lge. Mach. Cond. Outl.	Refrigerating Plant Temperatures Temp. Mixed at Bunker	Refrigerating Plant Temperatures Brine Inlet	Refrigerating Plant Temperatures Brine Outlet	Refrigerating Plant Pressures Brine	Refrigerating Plant Pressures Lge. Mach. Suction	Refrigerating Plant Pressures Lge. Mach. Discharge	Refrigerating Plant Pressures Sea to Lge. Mach.	Refrigerating Plant Pressures Ex. Port Lge. Mach.
229	90.1	89	109.6	111.7	384.7	389.4	45.0	52.5	46.2	14.3	10.6	13.6	25.25	209.3	43.25	18.1
201	100.8	91.6	111.6	113.4	385.0	393.8	42.2	45.9	44.8	21.6	16.0	14.1	44.6	45.35	104.3	14.6
182	87.6	80.4	102.6	111.8	382.0	391.6	38.0	44.6	39.8	30.9	24.1	11.3	34.5*	63.50	96.0	14.3

* Estimated

STANDARDIZATION TRIAL

Run	Knots	R.P.M. Stbd	R.P.M. Port	R.P.M. Ave.	S.H.P. Stbd	S.H.P. Port	S.H.P. Total	Steam Pressures Main Steam	H.P. Steam Chest Stbd	H.P. Steam Chest Port	H.P. Steam Chest Ave.	2nd Stage L.P. Steam Chest Stbd	2nd Stage L.P. Steam Chest Port	2nd Stage L.P. Steam Chest Ave.	Exhaust Stbd	Exhaust Port	Exhaust Ave.	Temperature °F H.P. Steam Chest Stbd	Temperature °F H.P. Steam Chest Port	Temperature °F H.P. Steam Chest Ave.	Nozzles Open Stbd	Nozzles Open Port	Nozzles Open Ave.
1	13.46	78.7	78.2	78.5	1551	1734	3305																
2	11.20	81.6	81.6	82.1	KVB	1742	3360																
3	13.36	79.0	78.8	79.1	1644	1676	3320																
Ave.	12.91	80.7	80.1	80.4	1608	1728	3336	245	134.3	137.3	135.8	24.3	25.0	24.7	16.8	11.8	14.3	247.7	244.1	245.9	384	385	384	8	8	8
4	13.30	95.7	93.9	95.5	5792	5794	11586																
5	15.25	90.6	90.8	90.7	2560	2962	5522																
6	13.44	92.5	93.3	92.4	2848	3768	6616																
Ave.	14.33	93.1	93.0	93.1	2679	3791	6406	247	194.7	196.3	195.5	37.0	44.0	38.5	11.0	6.0	8.5	207.0	199.5	204.3	385	385	385	8	8	8
7	19.75	106.8	106.4	106.6	3930	4127	8057																
8	15.46	108.2	108.2	108.2	4000	4000	8000																
9	16.50	105.5	105.1	105.3	4118	4120	8238																
Ave.	16.07	107.2	107.0	107.1	4016	4162	8176	254	200.7	200.9	200.8	35.0	63.0	39.0	16	0.0	0.8	214.9	210.8	212.5	391	397	394	11	11	11
10	18.65	126.0	124.8	125.4	6440	6365	12775																
11	19.08	124.5	124.4	124.5	6685	6670	13355																
12	19.91	126.3	126.0	126.2	6685	6687	13372																
Ave.	19.00	125.9	124.9	125.1	6611	6574	13234	249	241.0	237.7	239.4	41.0	101.3	67.6	5.0	7.8	6.4	286.5	279.0	282.6	404	409	407	14	14	14
14	19.76	126.0	124.4	125.5	6702	6344	13046																
15	18.05	125.8	125.1	125.9	6685	6590	13275																
16	19.41	125.2	124.5	125.4	6520	6640	13170																
Ave.	19.58	126.0	124.8	125.4	6669	6411	13074	249	248.0	240.0	244.0	98.0	125.7	101.9	57	8.2	7.0	283.0	281.8	282.6	403	406	405	14	14	14

Unless otherwise marked all pressures are in pounds gauge and all temperature are in degrees fahrenheit

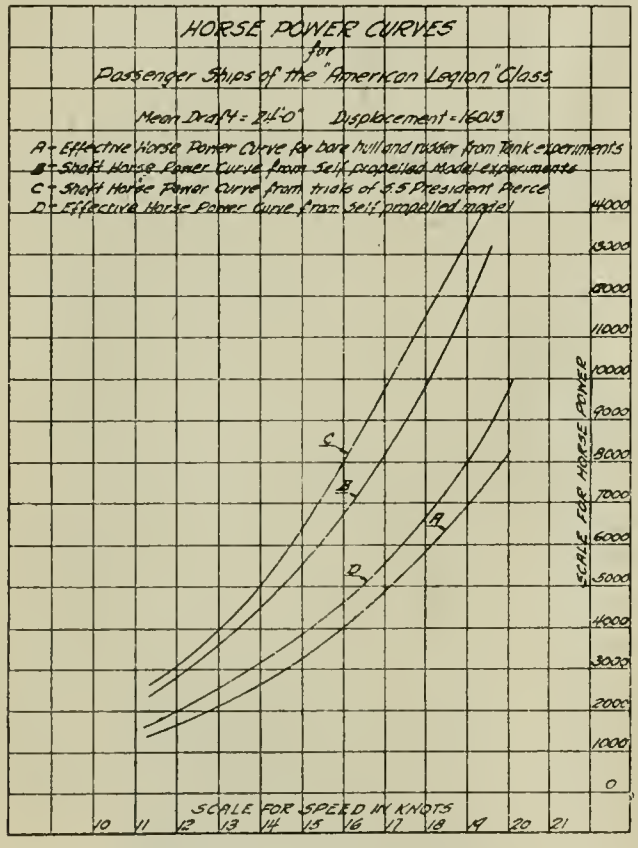
Barometer = 30.62"

Mean Draft during trials = 24'-0"

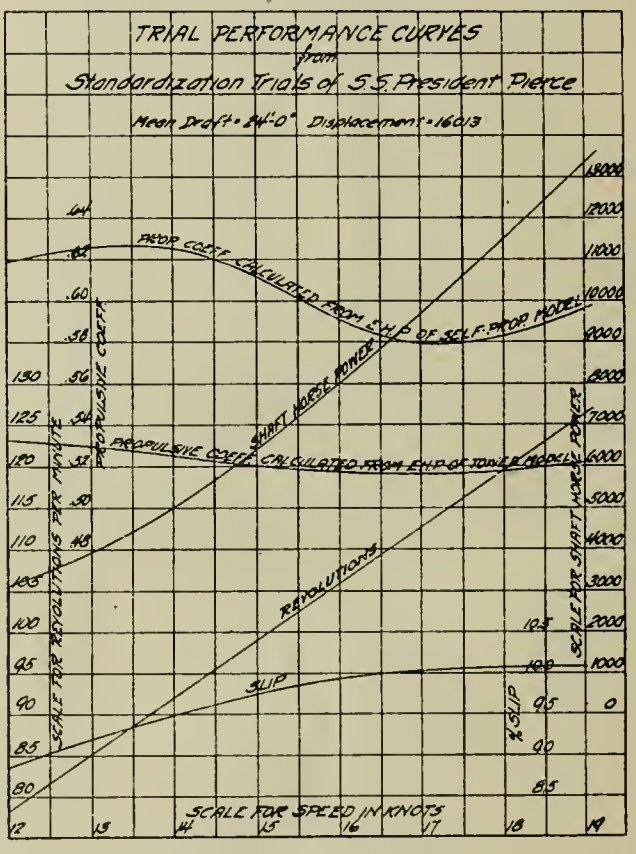
Mean Displacement during trial = 16013 Tons

Tabulated Results of Trials of T.S.S. "President Pierce."

Corporation, and five by the Bethlehem Shipbuilding Corporation Limited, at the Sparrow's Point plant. The machinery, therefore, while having the same general features, varies considerably in detail. The *Hawkeye State*, now the *President Pierce*, built at Sparrow's Point, is the vessel which was run through the standardisation trials, and it is the machinery of this ship which is briefly described in this paper. The engines are designed for 12,000 shaft horse-power on two shafts, and each shaft is driven by compound turbines through single-reduction gear. The turbines are of the Curtis type, and each high-pressure unit consists of twelve impulse stages. The first stage has a single wheel with two rows of 1-in. blading on a 36-in. diameter pitch circle. The remaining eleven stages each consist of one wheel with a single row of $\frac{3}{4}$-in. blading. The pitch circle diameter of these wheels varies from $34\frac{1}{4}$ in. in the second stage to $36\frac{1}{4}$ in. in the twelfth stage. The diaphragms between the wheels are of cast-iron with nickel-steel nozzle plates cast in and extend from the casing down


HORSE POWER CURVES
for
Passenger Ships of the "American Legion" Class
Mean Draft = 24'-0" Displacement = 16013
A = Effective Horse Power Curve for bare hull and rudder from Tank experiments
B = Shaft Horse Power Curve from self propelled Model experiments
C = Shaft Horse Power Curve from trials of S.S. President Pierce
D = Effective Horse Power Curve from self propelled model
SCALE FOR HORSE POWER
SCALE FOR SPEED IN KNOTS

Effective Horse-Power Curves.


TRIAL PERFORMANCE CURVES
from
Standardization Trials of S.S. President Pierce
Mean Draft = 24'-0" Displacement = 16013
PROP. COEFF. CALCULATED FROM E.H.P. OF SELF-PROP. MODEL
PROPULSIVE COEFF.
SHAFT HORSE POWER
PROPULSIVE COEFF. CALCULATED FROM E.H.P. OF TOWED MODEL
REVOLUTIONS
SLIP
SCALE FOR REVOLUTIONS PER MINUTE
SCALE FOR SHAFT HORSE POWER
% SLIP
SCALE FOR SPEED IN KNOTS

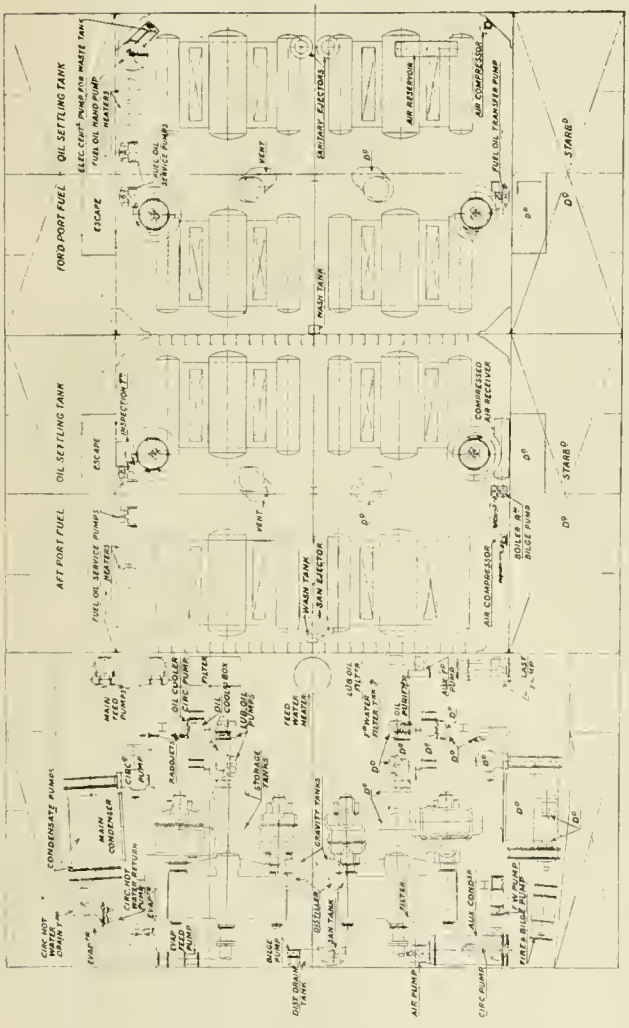
Trial Performance Curves.

to the hub of the wheels, where they are sealed by serrated brass packing.

The low-pressure turbines have seven stages, each stage consisting of a single wheel with a single row of 1-in. blading, and the pitch circle diameters vary from $49\frac{1}{2}$ in. in the first stage to 54 in. in the seventh stage. The diaphragms are of similar construction to high pressure. The astern turbine is located at one end of the low-pressure turbine and consists of two stages, each stage having a single wheel with two rows of 1-in. blading, and the pitch circle diameter is $36\frac{3}{8}$ in. for the first stage and $39\frac{1}{4}$ in. for the second stage. These turbines were built by the Fore River Plant of the Bethlehem Shipbuilding Corporation Limited. The first stage nozzles of both ahead and astern turbines are machined and carefully reamed to gauge. The first stage ahead has eight open nozzles—that is, only controlled by the main throttle valve—and two sets of three nozzles, each set controlled by an individual valve so that the power can be varied from 7,000 to 13,000 shaft horse-power in three stages so as to get the greatest advantage of full boiler pressure. One peculiar feature of these turbines is that the blading is all of the same hand, the right and left-hand rotation being obtained by turning one set of turbines end for end. When going ahead the steam flows aft through the port turbines and forward through the starboard turbines.

The reduction gears, built by the Falk Company, are of simple construction and of ample proportions. They are single-reduction gears with two pinions and main gear wheel in a single plane. The pinions are 9·143 in. in diameter at the pitch circle with 32 teeth, and the wheels are 131·143 in. in diameter at the pitch circle with 459 teeth. The width of the working face is 36 in. The pinions are made of chrome vanadium steel, heat treated, and the main gear wheel is of cast steel in one piece with the teeth cut in the rim. These gears have given excellent service so far and show every indication of having a long life. The main thrust, which is of the Kingsbury type, is incorporated in the forward end of the gear casing and is 25 in. in diameter. The line shafts are solid mild steel, $15\frac{3}{4}$ in. in diameter with solid couplings and are raised to 16 in. diameter for the bearings. The propeller shafts and stern tube shafts are $17\frac{3}{4}$ in. diameter with composition sleeves about $\frac{7}{8}$ in. thick shrunk on in way of bearings, the latter being of lignum vitæ. The line shafts are 169 ft. 5 in. long from the coupling of the gear shaft to the centre of the propeller, and each line has seven bearings 24 in. long. The bearings are lined with white metal and arranged for ring oiling.

The screw propellers are made of bronze, and are solid, three-bladed, 16-ft. 6-in. diameter, 17-ft. pitch, and each has 80·7 sq. ft. of developed surface and 69·4 sq. ft. of projected surface. They are machined to pitch on the driving faces, balanced and polished. The lubricating oil is arranged on the gravity system with two pumps, two coolers and one gravity tank to each engine. There is one V-shaped condenser to each engine with built steel shell, rolled brass tube plates



General Arrangement of Machinery of Vessels of the American Legion Class.

and cast-iron water ends. There are 4,405 $\frac{5}{8}$-in. diameter tubes, 10 ft. long between tube plates, making the cooling surface 7,200 sq. ft. A section of the bottom tubes is pocketed to form a cooling chamber over which the air and vapour must pass on their way to the air ejector suction. The turbines, condensers, condensate pumps, air ejectors and lubricating system make a complete unit for each shaft.

The boiler installation consists of eight water-tube boilers of the Yarrow type, arranged in two boiler rooms. The total heating surface in the eight boilers is 40,000 sq. ft. The tubes are 1-in. outside diameter, 0·095 in. thick, except for the two rows next to the fire which are $1\frac{1}{4}$ in. outside diameter, 0·019 in. thick. Superheaters of the Foster type are fitted, enclosed in the tube nest so that they can be drawn into the stokehold by removing the covering plate. The total superheating surface is 5,000 sq. ft., and they are located so that the temperature of the gases will be from 900° to 1,000° Fahr. The boilers have cylindrical steam drums, 4 ft. 2 in. diameter, and 12 ft. $9\frac{1}{8}$ in. long, which are large enough to furnish ample steam space and a reasonable amount of reserve water. The water drums are also cylindrical and are 2 ft. 6 in. in diameter. The boilers are oil-fired, using mechanical burners and closed stokeholes. The burners were originally of the navy type, but the stokeholes did not prove very comfortable and on the last two ships they were changed to Dahl burners, which resulted in the ships being able to make full power on natural draft and allowed of working under much more favourable conditions. The remaining three ships of this group will be changed accordingly.

It is not intended to give a full description of all the parts of this machinery, and it would be very wearisome to discuss all the various auxiliaries which make up the equipment. The arrangement of machinery in outline, together with the lead of the shafts and position of the propellers, is shown on this page. The distance from propeller tips to hull plating at the nearest point is 2 ft. $5\frac{1}{2}$ in. The model for the vessels of this class was towed in the tank at Washington, D.C., under various conditions, and the curves on page 464 show the effective horse-power and speed developed from these tests. The curves given are for hull with rudder. Some time later it was decided to make further tests on self-propelled model and the results of these are also given on page 464. On this test, the propeller represented those which were fitted on the American Legion. These are built propellers, three-bladed, with cast-iron bosses and bronze blades, 17 ft. diameter, 18-ft. 6-in. pitch, with a developed area of 84·4 sq. ft., and projected area of 71·400 sq. ft., and were intended for about 110 revolutions at full power. The curves estimated from the tests show the shaft horse-power, revolutions per minute, and propulsive efficiency at 24-ft., 30-ft., and 36-ft. draught. There has been added, for comparison, the estimated shaft horse-power, revolutions per minute, and propulsive efficiency, at 24-ft. draught for the propeller of the *President Pierce*. These are shown in dotted lines.

It has been noted that the propellers on the *President Pierce* vary from those used on the self-propelled model, the revolutions having been increased from 110 to 125 in order to obtain a more reasonable reduction gear. At the same time, the substitution of a solid wheel for a built wheel, and the machining of the driving faces, made the efficiency of the two wheels practically identical so far as could be calculated. The sea trials of the *President Pierce* were carried out at 24-ft. draught, the lowest at which the models were tested and the easiest at which to ballast the ship, with the loads arranged so that at the high runs of the standardisation trial, the draught would be as near as possible to the 24 ft. and as near as possible to an even keel. The weather on the runs was good, with very slight sea and light wind, so that there was no need to consider any correction from these conditions. The runs were made on the standard mile off the Delaware breakwater, and that course is rather shallow for a vessel of this size and speed, so there is probably some interference at the high runs. The depth on

the course varies from 23 to 25 fathoms, but the straight way leading up to the mile buoy at each end is considerably shallower, being from 19 to 22 fathoms at the north end and from 15 to 21 fathoms at the south end, and this again may have caused some interference so that the speed obtained is probably not quite so good as it would have been on a deep-sea trial.

Tabulated results of these trials are given on page 465. The bottom table shows the results for the standardisation at approximately 12, 14, 16 and 19 knots. It was intended to make five runs at the high speed, but the thirteenth run had to be thrown out on account of turn of tide, and this set was therefore split into two groups of three runs each. The speed results have been corrected for deviation. The shaft horse-power was obtained by means of Gary-Cummings torsion meters fitted to the two shafts next to the reduction gears, which were specially bored for the purpose, and the shafts were carefully calibrated in the shop with the torsion meters in place. The results of this trial are plotted on page 466, and alongside is a comparison of the effective horse-power, and shaft horse-power.

In order to obtain some data as to the performance of the turbine, water-measuring tanks were fitted and arrangements made for measuring the steam consumption of the starboard turbines. Six-hour runs were made at approximately 7,000 and 10,000 shaft horse-power and a twelve-hour run at full power, and the consumption was measured for the whole time. A short trial was also made at about 10,000 shaft horse-power for the purpose of measuring the steam consumption of the auxiliaries. The data for these trials are shown on the upper half of the table on page 465. It will be noted that the water rate is 10·70 at 13,043 shaft horse-power. The water is given uncorrected, except for a small allowance for Radojet steam. The consumption for auxiliaries showed rather high, 2·74 lb., but this is a condition which is partly inherent on a turbine ship and partly due to the extra auxiliaries needed in a passenger ship.

The results of these tests have been presented as candidly and completely as possible, and it is hoped that they will be of value to the members of the Society. It is to be regretted that after spending so much time and money that the final results should fall so far short of what one would wish, because one of the ships was not standardised on a course of sufficient depth to obviate any guessing at the true speed in deep water. The author wishes to acknowledge the courtesy of the New York Shipbuilding Company in furnishing the data on model tests and other information.

PREVENTION OF CORROSION AND SCALE.

The preservation of such metallic structures as boilers and condensers from corrosion is a problem with which engineers are continually contending. We understand the adoption of the Cumberland Electrolytic System for the prevention of corrosion and scale has been extensively adopted during the past few years with proved success. The system has been fitted to the *Mauretania*, *Aquitania* and to all the vessels of the Cunard post-war programme, including the *Berengaria*; it has also been installed in the White Star liner *Majestic* and a number of the company's other liners, Canadian Pacific liners, the "M" class vessels of the P. & O. Line, and vessels in the British and foreign navies.

The Cumberland system was first adopted for use in land installations and, we believe, was tried with success for the first time in the condensers of a well-known Atlantic liner. The method of fitting zinc slabs as an anti-corrosive has had long use. This method, it will generally be agreed, is anything but a success as its action is very local and therefore its preventive powers very small. The Cumberland system entirely supersedes zinc slabs. The principle on which it is based is the immersion, within the structure to be protected, of insulated iron anodes coupled to the positive pole of the source of electrical supply. Each anode is controlled by a separate resistance for regulating the current to a suitable density, and the affinity of these anodes for acid or oxygen is increased or diminished proportionate to the current supplied. The source of electrical supply is a rotary transformer of suitable capacity operated off the lighting or power current.

The surface which it is desired to protect is connected to the negative pole of the source of the electrical supply, and its affinity for hydrogen is also proportionate to the density of the current. The current flows from the positive pole, *i.e.*, the anodes, and passes through the water or electrolyte, decomposed by the current, to the surface to be protected, returning thence to the negative pole of the system generated. The flow of current attracts the oxygen, acids and other destructive elements in suspension or solution in the water to the anodes, gradually destroying them, and at the same time forming a film of hydrogen on the immersed surface of the unit to be protected. This hydrogen not only protects the surface from corrosion, but its mechanical action between the metal and the scale carries away into solution all dirt, scale and grease adhering to it.

The cycle of chemical reaction causes the chlorine and fixed salts of calcium (and magnesium if present) to disappear and calcium carbonate and sodium sulphate is formed as an equivalent. In the case of water containing calcium chloride this will be electrolised by the current, but there will be no simultaneous formation of sodium sulphate. If the structure to be protected is free from scale, the hydrogen evolved from its surface prevents the formation of any scale or any solid matter settling or adhering to it, and also neutralises any corrosive effects due to acids, oil, or free oxygen in solution. This sytem when applied to circulating water pipe lines, especially where sea-water or water contaminated with sewage effluent is used, prevents corrosion and choking of the inner surface by mussels, scale, weeds, marine and vegetable growths, thus materially reducing pipe friction, saving power, and avoiding the necessity of cleaning them at such frequent intervals.

The apparatus employed comprises a motor generator, or rotary converter run off the available source of supply, transforming it to low-tension current, together with a switchboard, ammeter, fuses, adjustable resistances, switches, insulated bolts, with anodes, and all special internal ironwork adapted to the particular type of vessel requiring protection.

This gear can be conveniently installed in the engine room and insulated wires run to the boilers, condensers, &c., to be protected, and once installed, is practically fool-proof.

Among the advantages claimed for the Cumberland system are that the initial cost may be stated to be the only cost as running and maintenance expenses are very low. Owing to the absence of corrosion and scale, the costs entailed by chipping and cleaning, painting, and the renewal of zinc plates, are entirely dispensed with, and the boilers and condensers can work at their highest efficiency with normal fuel consumption.

The system can also be applied to feed heaters, pumps, evaporators, tanks, pipe lines and to tail shafts and propellers.

TORSIONAL OSCILLATIONS OF REDUCTION GEARING.

Dr. Gümbel's Treatment of the "Melmore Head" Gearing—These Arrangements Described—Practice of Tuning the System—Apparent Justification.

The recent papers of Messrs. Wilkie and Smith presented at the Spring meetings of the Institution of Naval Architects gave rise to considerable discussion on the value of the nodal drive principle advocated by Dr. Smith, and apparently vindicated by the experience of the *Melmore Head* as described by Mr. Wilkie. The bulk of the contributors to the discussion placed accuracy of cutting as the paramount essential of all gearing, and to a certain extent they discredited the nodal drive recommended by Dr. Smith. A further interesting contribution to this nodal drive controversy has recently been made by Dr. Gümbel, the well-known German authority on marine engineering matters. This contribution appeared in the *Zeitschrift des Vereines deutscher Ingenieure* for August 26, 1922. In this article Dr. Gümbel expresses the opinion that while the critics of Dr. Smith's work were undoubtedly correct in stressing the overwhelming importance of accurate gear cutting, they acted perhaps a little short-sightedly in dismissing the importance of torsional oscillations in gearing problems. Adopting a slightly different method of

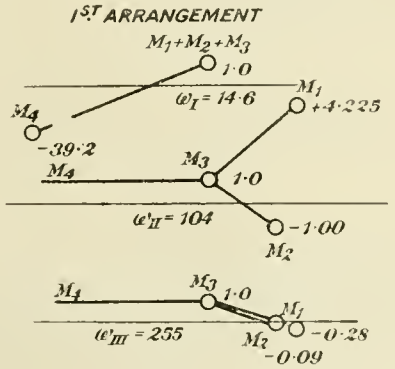


Fig. 1.

analysis from that of Dr. Smith, Professor Gümbel shows that while perfectly cut gearing is always to be desired, the practice of tuning up the system, which is the underlying principle of the nodal drive, is also to be recommended.

Preliminary Explanation.

Dr. Gümbel's treatment is based upon his previous contributions to the subject, and perhaps a little preliminary explanation is advisable before reproducing his analysis. This analysis is apparently based upon two simple principles. First, that at any instant of an oscillation the work done by the oscillating masses is zero; and second, that when the angular amplitude of vibration of one mass is known, that of an adjoining mass can be simply determined from the elastic properties of the intermediate shaft and the work done by the adjoining mass. To facilitate numerical calculation any actual system can be replaced by one dynamically similar, in which all shafts have the same angular velocity. In Dr. Gümbel's method this is effected by referring all rotating masses to the pitch circle radius of the main gear wheel. The equivalent mass placed at this radius can be conveniently used instead of the actual moment of inertia for all calculations in the problem of torsional oscillations. Using this substitution, we see that the work done by a rotating mass, in passing through an angular oscillation of unity, is equal to the kinetic energy produced by the normal uniform rotation of the mass, and equals therefore $\frac{1}{2} m \omega^2$, where ω is the angular velocity in radians per second. For any other amplitude of angular oscillation α the work done is $\frac{1}{2} m\omega^2\alpha$, and thus the first of Dr. Gümbel's principles may be expressed as $\Sigma\frac{1}{2} m\omega^2\alpha = 0$, or what is the same, seeing that the factor $\frac{1}{2}$ occurs in all terms of the summation, $\Sigma m\omega^2\alpha = 0$.

To understand the second principle it is necessary to recall that the work done in rotating one end of a shaft relative to the other, through one radian, is equal $\frac{NJ}{2l} = \frac{C}{2}$ where N is the modulus of rigidity of the material, J the polar moment of inertia and l and the length of the shaft and C is known as the shaft constant. The work thus required to produce a relative rotation of the ends of the shaft of α radians is therefore $C\frac{\alpha}{2}$. Thus if α_1 and α_2 be the angular amplitudes of the oscillations of the masses m_1 and m_2 and $C_{1,2}$ the constant of their connecting shaft, then we have, for the equilibrium of elastic external work,

$$\tfrac{1}{2} C_{12} (\alpha_2 - \alpha_1) = \tfrac{1}{2} m_2\omega^2\alpha_2$$

$$\text{or } \alpha_1 = \alpha_2 - \frac{m_2\omega^2\alpha_2}{C_{1,2}}.$$

A similar relation can be deduced for each pair of rotating masses and their intermediate connecting shaft throughout any system. This relation can be expressed generically as

$$\alpha_n = \alpha_{n+1} - \frac{m_{n+1}\,\omega^2\alpha_{n+1}}{C_{n,n+1}}.$$

These conditional equations are based upon the assumption that torsional oscillation is actually taking place, and thus for a given system over a range of rotation the real values of ω which are the simultaneous solutions of these conditional equations will correspond to critical speeds of rotation; and thus as n equations exist from which the n unknowns such as α_i can be eliminated the critical angular velocities ω_n can be obtained from the eliminant equations in terms of knowns such as m_i and $C_{i,i+1}$.

Dr. Gümbel's Treatment.

We will now proceed to Dr. Gümbel's actual treatment of the *Melmore Head* gearing. The dynamically equivalent masses at the high-pressure and low-pressure turbine pinions, of the propeller gear wheel and of the propeller itself are respectively designated by the symbols m_1, m_2, m_3 and m_4. The intermediate pinion effecting the double reduction is considered as absolutely rigid, and the shaft constants of the remaining connecting shafts are respectively designated by the symbols C_{13}, C_{33} and C_{43}. Perfect contact between the teeth of the respective gears is at first assumed. In the various arrangements adopted on the *Melmore Head* it can be safely assumed that the masses m_1, m_2 and m_3 and their respective shaft constants C_{13} and C_{23} are generally so large compared with m_4 and C_{43} that it is sufficiently accurate to consider the equilibrium of the masses m_1, m_2 and m_3 amongst themselves and that of m_4 and the sum of these masses m_1, m_2 and m_3. This assumption enables the critical speeds and the relative amplitudes of torsional oscillations to be very simply determined.

Case A.—m_4 oscillating against $m_1 + m_2 + m_3$.

$$\text{a. } (m_1 + m_2 + m_3)\,\omega_0^2\alpha_3 + m_4^2\alpha_4 = 0 \quad \ldots\ldots (1)$$

$$\text{from which } \alpha_3 = \frac{-m_4\alpha_4}{(m_1 + m_2 + m_3)} \quad \ldots\ldots (1a).$$

$$\text{b. } \alpha_3 = \alpha_4 - \frac{m_4\omega_0^2\alpha_4}{C_{43}} \quad \ldots\ldots (2)$$

and from (1*a*) and (2) we thus have—

$$\omega_0^2 = \frac{m_1 + m_2 + m_3 + m_4}{(m_1 + m_2 + m_3)m_4} \cdot C_{43} \quad \ldots\ldots (3).$$

Case B.—m_1, m_2 and m_3 oscillate against each other.

$$\therefore \text{ a. } m_1\omega_0^2\alpha_1 + m_2\omega_0^2\alpha_2 + m_3\omega_0^2\alpha_3 = 0 \quad \ldots\ldots (4).$$

$$\text{b. } \alpha_3 = \alpha_1 - \frac{m_1\omega_0^2\alpha_1}{C_{13}} \quad \ldots\ldots (5).$$

$$\text{c. } \alpha_3 = \alpha_2 - \frac{m_2\omega_0^2\alpha_2}{C_{23}} \quad \ldots\ldots (6).$$

from which we obtain—

$$\frac{C_{13}\,m_1}{C_{13} - m_1\omega_0^2} + \frac{C_{23}\,m_2}{C_{23} - m_2\omega_0^2} + m_3 = 0 \quad \ldots\ldots (7).$$

From this equation (7) two values of ω_0 can be obtained which, together with that available from equation (3), thus determine three critical speeds for the system. For the original arrangement on the *Melmore Head* (*see* Fig. 1) we have in Table I the following numerical particulars:

TABLE 1.

	Item.	m	C	ω_0 of the individual mass when shaft is completely constrained in gear case.
1	H.P. turbine	1·9	27,000	119·3
2	L.P. turbine	8·9	48.200	73·5
3	Gear wheel	1·33	64·25	14·4
4	Propeller	0·31		

and thus from equations (3) and (7) the critical speeds, and from equations (2). (5) and (6) the relative amplitudes of oscillation, become—

$$^{\omega}i_0 = 11{\cdot}6\,; \frac{\alpha_4}{\alpha_3} = -39{\cdot}2.$$

$$^{\omega}ii_0 = 101\,; \frac{\alpha_1}{\alpha_3} = +4{\cdot}225\,; \frac{\alpha_2}{\alpha_3} = -1{\cdot}00.$$

$$^{\omega}iii_0 = 255\,; \frac{\alpha_1}{\alpha_3} = -0{\cdot}28\,; \frac{\alpha_2}{\alpha_3} = -0{\cdot}09.$$

In the second arrangement adapted on the *Melmore Head* (*see* Fig. 2) we have the numerical particulars shown in Table 2.

TABLE 2.

	Item.	m	C	ω_0 of the individual mass when shaft is completely constrained in gear case.
1	H.P. turbine	1·9	27,000	119·3
2	L.P. turbine	8·9	1,850	11·4
3	Gear wheel	1·33	64·25	14·4
4	Propeller	0·31		

This second arrangement differs from the first because the shaft constant C_{23} was so "tuned up" by modification of the shaft diameter that the critical speed of the mass m_2 when its shaft end was considered as completely constrained in the gear case, should be equal to that of the mass m_4. The respective critical speeds and relative amplitudes of oscillation thus become

$$^{\omega}i_0 = 14{\cdot}6\,; \frac{\alpha_4}{\alpha_3} = -39{\cdot}2.$$

$$^{\omega}ii_0 = 28\,; \frac{\alpha_1}{\alpha_3} = +1{\cdot}06\,; \frac{\alpha_2}{\alpha_3} = -0{\cdot}36.$$

$$^{\omega}iii_0 = 188\,; \frac{\alpha_1}{\alpha_3} = -0{\cdot}67\,; \frac{\alpha_2}{\alpha_3} = -0{\cdot}006.$$

This second arrangement shows no improvement over the first arrangement, in fact it is actually worse because the second critical is brought nearer to the first and is almost exactly a whole multiple of it. There exists, however, an essential difference between the two arrangements. If the first critical is more accurately examined by rejecting the approximation that C_{23} is large compared with C_{43}, seeing that this is no longer tenable. it will be found that $^{\omega}i_0$ is not 14·6, but 14·4, and, moreover, that the masses m_1 and m_3 are at relative rest, and only the masses m_2 and m_4 oscillate against each other (*see* Fig. 2). It will be shown later what advantages accrue from this particular arrangement.

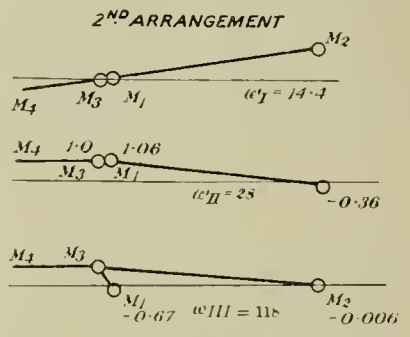


Fig. 2.

Finally, in the third arrangement adopted on the *Melmore Head*, all masses whose shaft ends were considered as completely constrained in the gear case were so designed as to possess the same free critical speed. This arrangement is shown in Fig. 3 and the corresponding numerical particulars are given in Table 3.

TABLE 3.

	Item.	m	C	ω_0 of the individual mass when shaft is completely constrained in gear case.
1	H.P. turbine and flywheel	10·2	2,120	14·4
2	L.P. turbine ..	8·9	1,850	14·4
3	Gear wheel ..	1·33	64·25	14·4
4	Propeller	0·31		

Since in this arrangement $\frac{C_{13}}{m_1} = \frac{C_{23}}{m_2}$ it follows from equations (5) and (6) that for each critical speed α_1 will equal α_2, and thus m_1. and m_2 oscillate with the same angular amplitude. We can thus replace these masses by a single mass $m_{1+2} = m_1 + m_2$ which can be assumed to be connected to the mass m_3 by a shaft whose constant has the value $\frac{C_{13}\,m_{1+2}}{m_1}$. The following simplified system shown in table 4 can thus be obtained.

TABLE 4.

	Item.	m	C	ω_0 of the individual mass when shaft is completely constrained in gear case
1 + 2	H.P. turbine flywheel and L.P. turbine ..	19·1	3,960	14·4
3	Gear wheel	1·33	64·25	14·4
4	Propeller ..	0·31		

For this system of three masses, in which m_{1+2} and m_4 oscillate against m_3, we obtain from equations (4) to (7)

$$^{\omega}i_o = 14{\cdot}4\,; \quad ^{\omega}ii_o = 57\,; \quad \frac{\alpha_1}{\alpha_3} = \frac{\alpha_2}{\alpha_3} = \frac{\alpha_4}{\alpha_4} = -0{\cdot}068.$$

Thus, by tuning up the individual systems to the same free critical, the number of criticals has been reduced from 3 to 2. While this fact is certainly advantageous it is not sufficient by itself to account for the actually observed improvement in this third arrangement.

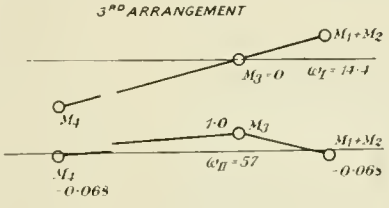


Fig. 3.

In order now to investigate the effect of movement of the gearing at a node, we must agree that the work done in an oscillation is transformed into disturbing forces and can be utilised for damping. The smaller the amplitude of vibration of the point of application of the external disturbing force, the smaller is the resulting work available for damping. When the point of application is at a node the external force, no matter what its magnitude may be, cannot set up free oscillations in the system. We now see that the advantage of the second and third arrangement on the *Melmore Head* lies in the fact that at an angular velocity $^{\omega}i_o = 14{\cdot}4$ no vibration could be produced in the system due to inaccuracies of gear cutting. In his final arrangement, Dr. Smith has reduced the number of criticals which are possible when gearing inaccuracies occur, from the three of the initial arrangement to one in the final corresponding to $^{\omega}ii_o = 57$. The possibility of vibrations being produced by the propeller on the propelling machinery still exists when $^{\omega}i_o = 14{\cdot}4$ even in this third arrangement. Dr. Smith, however, mentions in this connection that, for propelling machinery of the same type on several shafts and a twin-screw installation whose shafts are connected at the gear case, even these disturbing forces can be eliminated when the shafts are so placed that these forces oscillate in opposite phase. This suggestion is of the greatest importance when a vessel is to be propelled by several Diesel or steam engines whose shafts are united in one gear case.

In the foregoing investigation, perfect contact between the gear teeth has been assumed. The effect of unavoidable play upon the vibration will now be examined.

Consider, first of all, a gear corresponding to that finally adopted in the *Melmore Head* formed of two elastic systems, $m_{(1+2)}$ and m_{3a}, on one side in loose contact with each other and connected by a shaft whose constant is $C_{(1+2)3}$, and on the other side, m_{3b} and m_4, connected by a shaft of constant C_{34}, in which installation, neglecting the forces transmitted from the propeller, the shaft can be assumed to oscillate about a main position of zero stress. So long as both partial systems remain under stress during an oscillation, they may be considered as a single system, $m_{(1+2)}$, $m_{3a} + m_{3b} = m_3$, m_4. However, in passing through the mean position of zero stress, the system will divide itself into the two distinct parts considered previously as soon as any play is allowed to exist. Each mass forming each partial system moves with an additional velocity in passing through the mean position. This increase in velocity can be split up as follows :—

1. A uniform velocity equal to that of the centre of gravity of the combined masses of the partial system when passing through the unstressed condition ; and

2. A periodic velocity of period corresponding to that of a free oscillation of the individual masses round the common centre-of-gravity, and whose maximum velocity supplements the centre-of-gravity speed and the speed of the masses in passing through the unstressed condition.

If we consider two masses M and m forming such a system and which are connected by a shaft whose constant = C and whose velocities of oscillation in passing through the unstressed condition are V and v respectively, it follows that the uniform velocity of the centre of gravity in passing through the region of play will be given by

$$v_e = \frac{VM + vm}{M + m} \qquad (8)$$

and the additional periodic velocity of the mass M becomes

$$(V - v_e) = \frac{(V - v)\,m}{M + m} \qquad (9)$$

and of the mass m

$$(v - v_e) = -\frac{(V - v)\,M}{M + m} \qquad (10).$$

The angular velocity of this additional periodic oscillation is given by

$$\Omega = \sqrt{\frac{C\,(M + m)}{Mm}} \qquad (11)$$

and is thus greater than the angular velocity of the outward oscillation. The amplitude of this supplementary periodic oscillation is given by

$$\frac{V}{\Omega} \text{ or } \frac{v}{\Omega} \qquad (12).$$

In practice these relations may be simplified. Assume in the *Melmore Head's* final arrangement that the mass of the pinion is small compared with the sum of the turbine masses, and also that the propeller mass is small compared with that of the gear wheel. Thus, if $\alpha_{(1+2)}$ is the amplitude of oscillation of the turbine mass and α_3 that of the gear wheel, the pinion moves, through the play, with a uniform velocity, $\omega\alpha_{(1+2)}$, and the gear wheel with the velocity $\omega\alpha_3$. Under the assumption of oscillation round the unstressed position, the gear wheel teeth engage with the opposite flanks on the pinion after a time equal to

$$\frac{s}{\omega(\alpha_{(1+2)} - \alpha_3)}.$$

The time of a completed oscillation thus changes, due to play, from

$$T = \frac{2\pi}{\omega} \text{ to } T = \frac{2\pi}{\omega} + \frac{2s}{\omega(\alpha_{(1+2)} - \alpha_3)}$$

and thus the critical angular velocity reduces to the value

$$\omega_o \left(\frac{1}{1 + \frac{s}{(\alpha_{(1+2)} - \alpha_3)\pi}}\right)$$

and is thus dependent upon the ratio of the play to the amplitude of oscillation. In this respect also, the final arrangement of the *Melmore Head* is superior to the first. The engaging of the teeth takes place with a finite velocity, $\omega_o(\alpha_{(1+2)} - \alpha_3)$, and thus acts in the nature of a shock. The shocks produced

by oscillation and by the play between the teeth are the explanation of the teeth fractures observed in practice. In order to prevent them, both play and oscillation should be avoided. If only play is eliminated, the possibility of high-tooth pressures still exists, due to torsional oscillation. The alteration in the critical speed, brought about by the presence of play, makes the calculation of the critical speed with perfect contact only of practical use in placing a superior limit to the value that the critical is likely to attain. In considering this critical speed one must remember that resonance with this speed can take place at lower speeds, due to play, and will in fact be greater, the greater the play.

This unreliability of calculation as well as the impossibility of estimating the number of impulses likely to be produced by errors of gear cutting, coupled with the desire to reduce all shock produced by torsional oscillation to a minimum, emphasises the importance of artificial means of damping the oscillations. This was referred to by Sir Charles Parsons in his contribution to the discussion on Dr. Smith's paper.

In reviewing the experience of the *Melmore Head* it is, however, evident that the practice of tuning up the system, as advocated by Dr. Smith, is apparently justified, and is likely to produce successful results without the necessity of introducing any artificial means of damping the oscillations.

INSTITUTE OF MARINE ENGINEERS.

Twenty-seventh Annual Dinner at the Hotel Cecil.

On Friday, November 3, the twenty-seventh annual dinner of the Institute of Marine Engineers was held in the Grand Hall of the Hotel Cecil, London. The President, Engineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D., was in the chair, supported by fully 700 members and guests, and a most enjoyable evening was spent. Several interesting speeches were made during the course of the evening, particularly with reference to naval, shipbuilding and marine engineering matters of considerable moment at the present time.

In proposing "The Shipbuilding and Engineering Industries," Vice-Admiral Sir George Goodwin, said that in certain quarters he had been accused of condemning the electric drive, but he believed that there was a great future for it in certain classes of ships, if it were coupled with Diesel engines. The shipowner was something in the nature of an Oliver Twist—always asking for more and better things on the engineering side of his ships. The Institute of Marine Engineers had always been ready in that direction. There was still no serious rival to steam for ships of high power. The oil engine had come to stay, and for ships of lower powers it could be trusted to hold its own with success. The Special Committee engaged on trials of various types of Diesel-engined ships hoped to be able to publish the results of these trials very soon, and he was sure these would prove of the highest value to the nation as a whole. He would repeat that he believed the combination of the Diesel engine with electrical transmission for certain classes of merchant ships held the greatest promise.

In reply, Mr. J. Herbert Scrutton, Chairman of Lloyd's Register, said that, in presiding over a Committee which was representative of greater interests than any other Committee in the world, he felt humble when confronted with problems put before him every day by engineers and naval architects, inasmuch as he had no training in the business. He recalled the fact that Lloyd's Register had provided the Institute with many officers. The shipping industry had been feeding on the remains of the feast for some time, and was up against trade conditions to-day. The lean years were, he thought, slowly passing over, and they were gradually returning to the position of pre-eminence held before the war.

Proposing the toast of "The Mercantile Marine and Overseas Dominions," Sir H. Eustace Tennyson d'Eyncourt, K.C.B., F.R.S., D.Sc., referred to the great part played by the mercantile marine during the war. At present the mercantile marine was suffering from a world-wide depression, due in part to over-production of tonnage, the general slump in trade, and the instability of the exchanges. It would be a difficult matter to run at a profit many of the older vessels which the war had kept on the seas longer than they might normally have been. New tonnage and more efficient tonnage would be necessary when these older ships were scrapped, and it was here that the marine engineer could help the mercantile marine of the future by continually improving the economy both of the type of ship and machinery, so that the fuel and running expenses would be reduced to the minimum.

The toast of "The Chairman," given by Commander Sir Trevor Dawson, Bart., R.N., was received with great enthusiasm. Sir Trevor Dawson described briefly the distinction with which the Chairman had held the position of Engineer-in-Chief of the Fleet for a period of five years. He had commenced his naval career at Portsmouth Dockyard, and had passed his examination as naval engineer so satisfactorily that the Admiralty gave him eight years' seniority as a mark of their high appreciation. He had been for 10 years the coadjutor of that distinguished engineer, Sir Henry Oram, and succeeded that officer in 1917 in the highest position which the Navy offers to the engineering profession. He had held many important appointments in the Naval Service, having been Chief Engineer of Chatham Dockyard in 1904, Deputy Engineer-in-Chief at the Admiralty, 1907, and Engineer-in-Chief of the Fleet, 1917. He was honoured by being given the Order of the Companion of the Bath in 1913, and was promoted to a knighthood of this Order in 1918.

The dinner arrangements were admirably carried out by the convener, Mr. Alfred Robertson, assisted by the following committee:—Messrs. Geo. Adams, Jas. Adamson, J. Clark, A. E. Crighton, Jas. M. Dewar, B. P. Fielden, J. B. Harvey, Robert Leslie, O.B.E., A. H. Mather, J. McLaren, J. Shanks, A. K. Sowter.

The following acted as croupiers:—Messrs. E. M. Salmon, J. Thom (Member of Council), A. H. Mather (Vice-President), B. P. Fielden (Vice-Chairman of Council); Robert Leslie, O.B.E. (Vice-President), John Clark (Chairman of Council), John Silley, Geo. Adams (Vice-President), F. M. Timpson (Vice-President), Jas. Carnaghan (Member of Council), F. G. Butt Gow, D. Casebourne, H. F. Bond, T. Fleming, O. B. Richardson (Member of Council), and G. J. Wells.

The Marine School of South Shields.

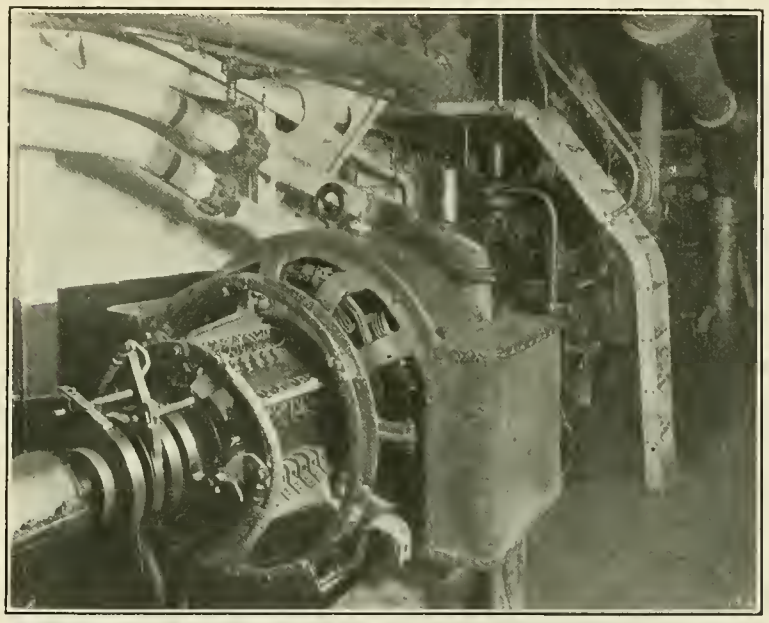
At a meeting of the Governors of the Marine School of South Shields, a few days ago, Mr. H. R. Cullen, M.A., the principal, reported that the number of Board of Trade certificates obtained by students of the Marine School now exceeds 10,000; the number up to the present time being 6,792 in navigation from the year 1862, and 3,430 in marine engineering from the year 1903—total, 10,222. The Board of Trade have granted only eighteen certificates altogether in the kingdom for extra chief engineer at the four examinations which have been held for this grade this year; of these twelve have been obtained by students of the Marine School of South Shields. This means that two-thirds of the successes have gone to the Marine School, and one-third to the rest of similar schools in the whole country.

MAIN PROPELLING MACHINERY OF U.S.S. "TENNESSEE."—II.*

Motor Ventilating Arrangements—Preliminary Damage and Repairs to No. 4 Main Motor—Details of Propellers, Boilers and Official Trials.

In continuation of this article, the first section of which appeared in the October issue of *The Marine Engineer and Naval Architect*, we describe below the remainder of the equipment and the final official trials.

The liquid rheostats for the main propelling motors, are built in pairs, that is, one double rheostat serves two motors. They consist of a lower electrolyte storage tank, and two upper electrode tanks. The lower tank is connected with the electrode tanks through centrifugal pumps, and there is an overflow from the upper to the lower tanks so that the electrolyte can circulate. The centrifugal pumps pump the electrolyte from the storage tank to the electrode tanks at a predetermined rate which can be adjusted by means of a valve in the pump suction. This fixes the rate of acceleration. For normal operation it takes about 17 sec. from minimum to maximum level and about 15 sec. for the reverse operation. The electrode tanks have a valve at the minimum liquid level which, when open, allows the electrolyte to circulate through the tank with a part of the longest electrodes immersed. This is the starting position of the rheostat. When it is desired to accelerate this valve is closed through the operating handle and the level of the electrolyte rises until the overflow is reached. At this point the electrolyte will continue to circulate and there is minimum resistance in the motor circuit. Provision is made by means of a handle at the top of the rheostat to connect two electrode chambers together. This can be done either for equalizing the level of the liquid, or in case one of the pumps is out of commission, one pump can fill both chambers at a slower rate.



300 kw. Turbo-Generating Set as Installed on the U.S.S. "Tennessee."

The lower tank is provided with cooling coils which may be used if it is found necessary due to operating conditions, although ordinarily they will not be required. The electrodes are iron plates supported by special moulded insulators and can be removed as a unit. A vent pipe is provided to allow the escape of any vapour.

The liquid used in the rheostats is a $1\frac{1}{2}$ per cent. solution of sodium carbonate (Na_2CO_3), known commercially as soda ash. The resistance between phases is about ·03 ohms, with maximum liquid level and ·35 ohms with minimum level.

In arranging the motor to perform all manœuvering on the 24-pole connection, the turbine speed does not have to be changed for shifting to 36-pole operation. This is due to the fact that when power is removed the propeller r.p.m. drops immediately to about 70 per cent. This insures a quick shift which is sufficiently rapid to allow it to be done in fleet formation without losing position. Severe strain is also prevented on the windings during the switching operation.

For gaining access to all parts of the motor for examination or repair, the foundations are extended to the forward bulkhead. The stator can be slid forward on these extended foundations a sufficient distance to completely uncover the rotor. The motor feet are grooved to fit a key laid and bolted to the foundations, which keeps the stator moving parallel to its axis. This insures the windings against damage even with the small air gap of ·120 in. In order to disassemble, it is necessary to (1) unbolt the after bearing bracket; (2) remove the forward upper bearing housing and bearing; (3) fit an extension shaft, one end inserted into the motor shaft and the other end resting on a saddle foundation at the forward bulkhead; (4) unbolt and lift clear the blower motors, foundations and ventilating ducts; (5) disconnect and clear the cable connections; (6) remove incidental piping and gear such as oil piping, counter gear, floor gratings and supports. After practice a motor has been disassembled, examined, reassembled, and put back in service in less than 24 hours.

The stator windings are provided with six thermo couples, three for each winding, located in the slots between top and bottom coils for the purpose of measuring the hot spot temperature. The leads from the thermo couples are lead to the control room so that temperature readings from all main units can be read at one point which is under the direct supervision of the watch officer.

The shaft is of nickel steel, with the coupling forged integral. The shaft is hollow, having a 9-in. hole in the centre throughout its length.

The three collector rings are of brass, and are assembled on a cast-steel hub which is pressed on and keyed to the shaft. Special care is taken in the assembly of the rings to provide highest type of insulation. The brush rigging is assembled on a suitable casting and bolted to the forward bracket. A fitted sheet steel pan is installed beneath the brush riggings, so that any loose parts or broken brushes will be prevented from dropping into the windings.

Ventilating Arrangements.

Ventilation is provided by two 750 to 1,200 r.p.m., 10,000 cub. ft. per min., variable speed, motor-driven exhaust fans.

* Abstract of Paper read by Lieut.-Commdr. C. A. Jones, U.S.N., before the American Society of Naval Engineers, and published in the Journal of that Society.

They are mounted on top of a sheet steel casing which encloses the motor frame and serves to confine and direct the cooling air. In addition the rotor of each motor is provided with fans, so that in case of failure of the separate motor-driven fans operation could be continued for a short period. The cooling air enters the motor room through an armoured natural ventilating duct which leads down from the quarter deck. At the base of this duct, a false watertight deck is installed over the cables and buss structure to prevent damage from any water which might enter. The exhaust blowers draw the cooling air from the room through screened openings in the motor brackets, over the coil ends, through the air gap and axial ducts in the stator, and rotor cores formed by punched holes in the laminations, and thence through a radial duct located centrally in the cores to the chamber formed by the sheet metal casing around the frame. Here the air enters the exhaust fan which forces it up through an armoured duct where it is discharged on the quarter deck. Provision is made against damage by water entering the motor from the discharge duct by a large trap at its base which has a drain to the bilge. All discharge and supply ducts on the weather deck are carried well above the deck, and fitted with special channel deflecting shields around the trunk and with a special type hood over the trunk. In very cold weather the motor room is heated by passing a part of the heated air discharge from the blower back to the room. An adjustable shutter in the discharge duct is provided for this purpose. The intake duct to the blower is also provided with a damper so that, if necessary, only one blower can be operated.

General View of Control Room on the U.S.S. "Tennessee."

Preliminary Damage to Main Motor.

On March 12, 1921, number 1 main motor was damaged to such an extent by a short circuit that it was necessary to completely rewind both rotor and stator. The short also, due to the intense heat developed, fused three of the slots in the stator so that about 10 per cent. of the iron laminations had to be renewed. The fused portion of the slots extended from the after end to the central radial air duct. After giving all phases of the question of rewinding careful consideration, it was decided to do the work on board ship and away from a Navy yard. The ship was at Guantanamo, Cuba, at the time of the casualty, so proceeded to Hampton Roads, Va., where the material was assembled. The work was done under the direct supervision of the contractor's service engineer. The direct labour was performed by eight winders and one iron worker from the Westinghouse works, assisted by picked men from the engineer force of the ship.

Complete rewinding would not have been necessary except that no provision had been made for extinguishing a fire in the windings of the motor, so that salt water had to finally be used for that purpose. All motors, both in service and new construction, will be fitted with a special sprinkling system connecting with the boiler water feed mains for extinguishing a fire resulting from a short circuit. In this way coils not damaged mechanically will be saved.

Although the exact cause of the accident could not be definitely determined, it has been practically agreed that it was caused by some foreign substance getting between the moving and stationary coils, thus injuring the insulation. The wire mesh screening fitted over the openings in the brackets for the entrance of the cooling air was of very coarse mesh, about 1-in. opening. This was replaced on all the motors with heavy screening, having about $\frac{1}{8}$-in. opening.

During the rewinding of number 4 motor the other three motors were completely disassembled, examined carefully, sprayed with varnish, given a high potential test, and reassembled by the ship's force. This was in order to provide every precaution against the recurrence of the casualty to number 4 motor.

The question of baking the varnish properly after spraying the windings was quite a problem to accomplish on board ship. This baking had to be done at about 100 deg. C. and six coats of this insulating varnish had to be sprayed and baked on. This was effectively accomplished by using twenty-five 3,000-watt electric heaters, supplied for heating various parts of the ship, and using the entire motor room for an oven.

During the progress of the work the ship proceeded to the naval proving grounds at the mouth of the Pontomac River and carried out the test firing of her entire battery. After this she proceeded to Boston, Mass., for docking, previous to standardisation and machinery trials, and thence to Rockland, Me., arriving there on May 12, 1921. It was thus only two months from the breakdown in Cuba until she was ready for final trials at Rockland.

With the repairs in progress it was possible, as demonstrated by actual runs, for the ship to steam in the open sea up to speeds of about 15 knots.

Main Thrust Bearing.

This bearing is a standard 29 in. Kingsbury type and contained in an oil-tight housing with two steady bearings. The collar forged integral with the shaft has bolted on each side, face plates which bear against the shoes. These face plates are made in halves so that they can be readily renewed.

The face of the bearing shoes are babbitted but a spare set of bronze shoes are carried. The shoes are carried on levelling plates which insure equal division of the load between the shoes. The housing is supplied with oil from the after forced lubrication system and has an overflow in the top which causes it to be continually full of oil.

A water circulating cooling coil is fitted in the top of the housing to assist in carrying off the heat. The bearing was designed to operate at full power with failure of both lubricating oil and water supply. It has been recently demonstrated on full power trial of the U.S.S. *Maryland* by actual test that this can be done.

Propellers.

There are four three-bladed propellers, cast with blades integral with the hub. The starboard propellers are right-hand and the port propellers left-hand, all propellers turn outboard when driving the ship ahead. They are of manganese bronze and the hubs are taper bored to fit the shafts, to which they are secured by a key and locked nut. The ahead face of the blades are machined true to pitch and the propeller polished all over including the hubs. They are given a static balance on knife edges and sufficient metal removed from the backing face of the blades to obtain balance.

Propeller Data.

	Ft. in.
Diameter	13 6
Hub	2 9
Pitch	14 3
Ratio of diameter to pitch	·9474
Area—	**Sq. ft.**
Projected	52·1
Helicoidal	61·98
Ratio—	
Projected to disc area	3·64
Helicoidal, to disc area	·4333
Height of lower tip of blade above keel—	**Inches.**
Inboard	9
Outboard	17·17
Immersion of upper tip of blade—	**Ft. in.**
Inboard	16 0
Outboard	15 3·83

Boilers.

There are eight Babcock & Wilcox water-tube boilers, each located in a separate watertight compartment.

The boilers are equipped for burning fuel oil, each boiler having six burners of the Peabody mechanical atomizer type, They have a total heating surface of 41,768 sq. ft., exclusive of superheating surface, and are designed with sufficient power to operate the entire machinery plant at full power.

A great deal of trouble had been experienced by the oxidising of the brick work retaining bolts. After thorough investigation of the subject "calorized" bolts were fitted. There were also installed a number of monel metal bolts for experiment.

Due to deflection of the fire tubes on boilers of similar type on former ships at full power, an internal feed pipe was installed for discharging the water directly into the down-comers. Near the point of discharge to the down-comers a valve was placed in this line with provision for outside operation so that it could be opened or closed as desired. At ordinary powers the feed water is discharged through an internal feed pipe which extends the length of the drum, the openings being on the top of the pipe. The use of the discharge into the down-comers continuously would cause rapid corrosion of the tubes and down-comer.

Trials.

The final official trials of the *Tennessee* were held from May 12 to 16, 1921. Just previous to the trials the ship was docked at Boston, Mass., for cleaning and painting the underbody. The ship averaged 21 knots on the high speed runs at a displacement of 33,367 tons, developing an average shaft horse-power of 29,868. The maximum shaft horse-power developed was 30,909.

The principal average data obtained on the trial is given in the following tables. Where propelling machinery is referred to it includes certain of the main turbine auxiliaries as follows: Exciter, main circulating pump, condensate pump, air ejectors, oil cooler circulating pump and lubricating oil pump. It also includes the main motor ventilating fans and liquid rheostat pumps.

Steaming Trial Data.

	4 hour full power trial.	8 hour 28,000 S.H.P. trial.	12 hour 19 knot trial.	12 hour 15 knot trial.	12 hour 10 knot trial.
Average speed, knots	21·01	20·75	19·00	15·00	9·99
Displacement, tons	32,878	33,025	33,233	33,388	33,245
Average, s.h.p.	30,229	27,944	20,463	9,357	2,762
Total oil consumption per hour (18750 B.T.U.)	34,304	30,218	21,746	9,730	6,436
Oil consumption per s.h.p. per hour	1·135	1·081	1·063	1·040	2·33*
Oil consumed per sq. ft. heating surface per hour	·821	·723	·521	·466	·411
Oil consumption per knot lb.	1633	1456	1144	649	644*
Water consumption, main propelling machinery per s.h.p. per hour	12·486	11·976	11·568	11·582	14·904
Number of boilers used during trial	8	8	8	4	3
Steam at—					
Boilers, lbs. gauge	270	271	263·5	260·4	260·1
Turbine, lbs. gauge	246	249	252	250	253
Turbine, temperature deg. Fahr.	419	427	432	427	430
Vacuum, in.	28·62	29·00	29·0	29·4	29·4
Barometer, in.					30·17
Fireroom, air pressure, in. of water	5·5	4·7	3·0	3·4	2·8
Shaft, r.p.m.	170·8	167·2	152·3	117·8	77·9
Slip of propellers, per cent.	12·51	11·72			

*On account of having to use No. 1 nozzle partially open on the after turbine on the 12 hour 10 knot run, a short run of two hours was made at 10 knots with the forward turbine which showed oil consumption of 1·91 lb. per s.h.p. per hour and 505 lb. of oil per knot.

Special reversing and turning tests were run in order to subject the machinery to severe tests and to obtain necessary design data.

Backing Trial Data.

	From full power.	From 19 knots.	From full power one generator.	From 15 knots.
R.P.M. just before signal to back	169·5	160·1	130·4	127·7
Time of signal to back, min. and sec.				
Motors started to back, min. and sec.	0 15	0 17		
Ship dead in water, min. and sec.	3 0	2 58	4 16	3 52
Head reach, yards	1,009	730	915	840
Average r.p.m. maximum backing	130	130	100	100

All trials were successfully completed without machinery casualty of any kind. All contract guarantees were fully met.

A METHOD OF BURNING SOFT COAL IN MARINE BOILERS.

Brief Description of Installation as fitted on Reclamation Dredger "Child."

In order to enable coal of an inferior quality, such as soft coal, to be burned, the system described and illustrated below has been used with considerable success. It has the advantage that it can be fitted to any steamer without disturbing the boilers or machinery, and further, it is easily put out of action when not required, *i.e.*, when coal of good quality is obtainable.

To consume completely the inflammable gases given off by the fuel, extra air is admitted to the combustion chambers, and in an ordinary marine type boiler this is done by way of a few of the lower row of tubes. This air is not forced, but caused to flow in under gentle pressure, thus giving it ample time to mingle with the unburnt gases in the combustion chamber.

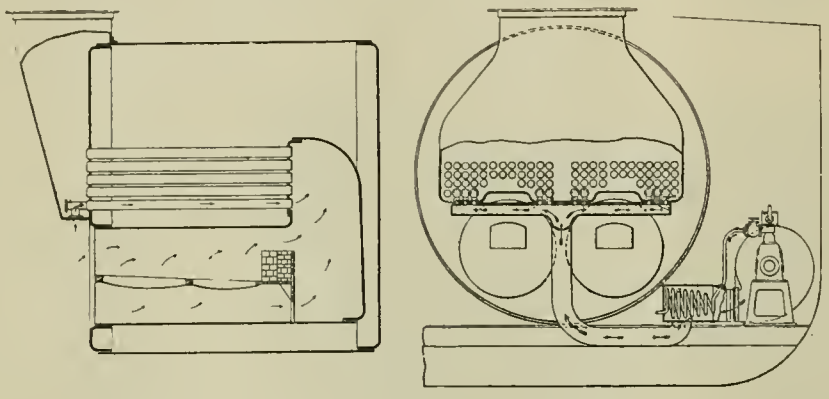
The system, as fitted to a small marine boiler, is shown above. It will be observed that air-ducts are fitted along the exterior of the bottom plates of the uptakes and connected by means of elbow-pieces with as many of the lower row of tubes as may be necessary. These elbow-pieces, as shown in the detail drawing reproduced above, are constructed so that they may be opened by the removal of a cap at the outer end for cleaning the tubes.

The main duct is supplied with air by a fan, the speed of which may be regulated so as to provide the right amount of air. The air may, if desired, be preheated, as shown. In the boiler under consideration all the tubes in the bottom row are fitted with elbow-pieces, but this is not always necessary. Suitable openings, which can be closed by sliding doors, are provided in the air-duct for cleaning out any accumulation of dust.

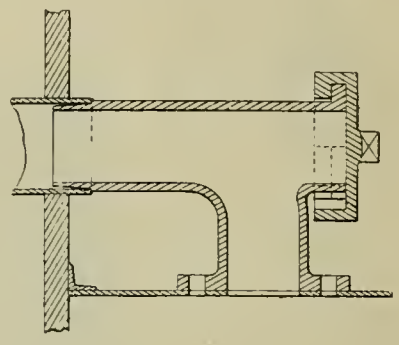
One engineer, on being shown this system, objected to it on the grounds that the comparatively cool air issuing from the inner ends of the tubes would strike against the back plates of the combustion chambers, causing cracking or buckling. In practice, however, what occurs in the chamber is similar to the action of a jet of air ignited in an atmosphere of hydrogen, a common laboratory experiment. The air issuing from the tubes is immediately involved in combustion and becomes flame almost at once, it is then diverted by the draught from the furnace into the return tubes.

It is essential that the extra air thus admitted should flow in gently under a pressure of from a quarter to half an inch of water, and that the speed of the fan should be regulated so as to maintain this. If the pressure becomes too great, combustion may take place in the uptakes and cause overheating there, as occurs when fuel of this type is burned under forced draught conditions. When good coal is obtainable the system may be put out of action by merely stopping the fan and firing as usual.

This method was applied to the Reclamation Dredger *Child*, working in Lagos Harbour, the result being almost smokeless combustion of the local "soft" coal, and a reduction in the daily consumption of nearly 25 per cent.



Arrangement of Air Ducts on Small Marine Boiler.



Smoke Tube Elbow-Piece.

MOTOR LIFEBOATS FOR THE ROYAL NATIONAL LIFEBOAT INSTITUTION.

Already this year the Royal National Lifeboat Institution has completed and sent to the coast no fewer than five new motor lifeboats, and another two recently finished their trials and left the building yard at Cowes for their stations. These are the boats for Bembridge, in the Isle of Wight, and for Barry Dock, near Cardiff. The Bembridge boat is a self-righting lifeboat, 40 ft. by 10 ft. 6 in., fitted with a Tylor engine of 45-h.p., and on her trials she showed a speed of just over 7 knots. She is a sister boat to those which have already been sent this year to Appledore, Brixham, Sennen Cove and Selsey, has been built out of a leagcy generously left to the Institution by the late Mr. Thomas George Langham, of Great Wigston, Leicester, and is named *The Langham*. The Barry Dock boat is of the Watson type, 40 ft. by 11 ft., is fitted with a 45-h.p. Tylor engine, and also showed a speed on trials of just over 7 knots. She is one of the two boats, the other being for The Mumbles, Swansea, for which a special fund is being raised in Glamorganshire with the intention of presenting them to the Prince of Wales as a thank-offering for his safe return from his world tours. Out of the Institution's fleet of 241 lifeboats, 37 are now motor lifeboats, while another seven motor lifeboats are under construction.

Institution of Naval Architects.—The Spring Meetings of the Institution of Naval Architects will commence on Wednesday, March 21, 1923.

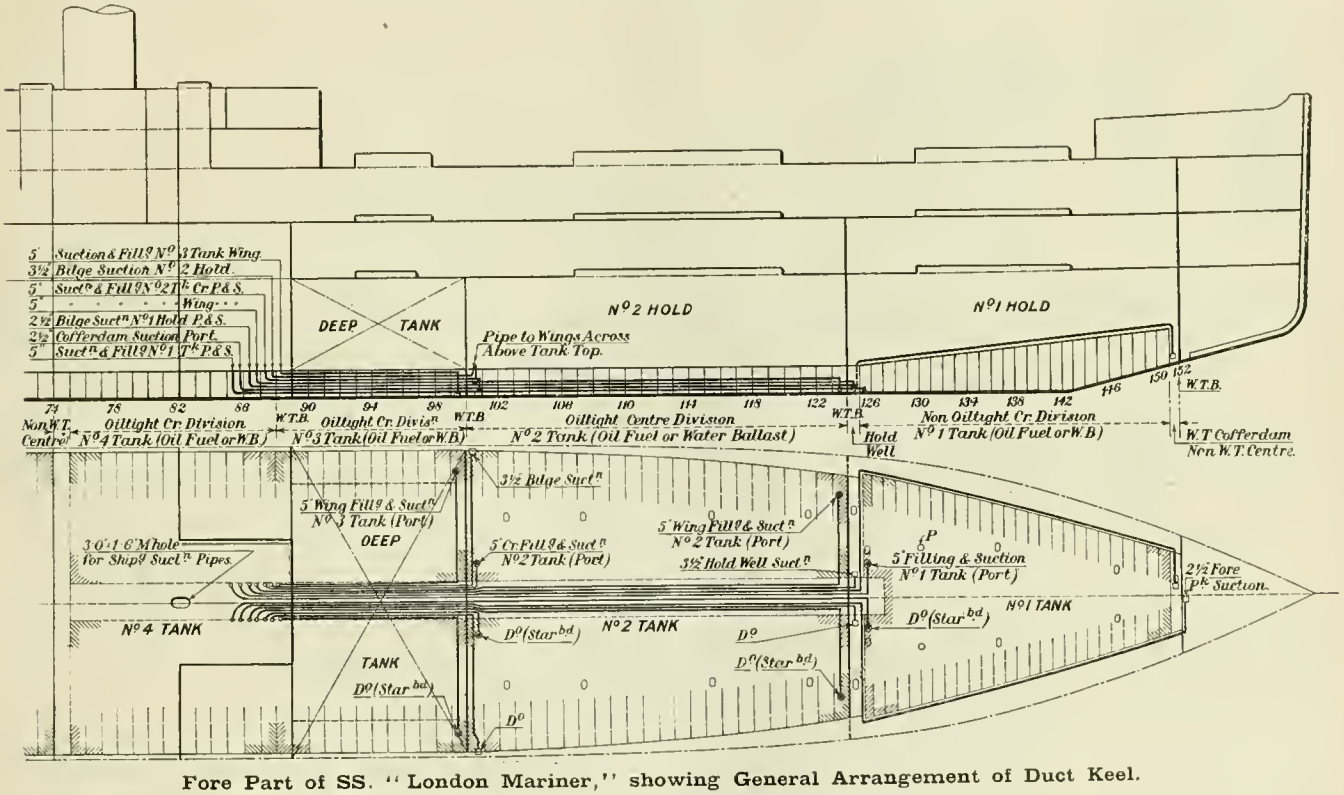
THE DUCT KEEL.

Particulars of the Duct Keel as fitted in the Fore Part of SS. "London Mariner," built by the Furness Shipbuilding Co., Haverton Hill-on-Tees.

Broadly speaking the safety of a vessel is almost wholly dependent upon the nature and extent of the subdivision adopted, and recognising this essential, the Bulkhead Committee, appointed in 1912, and subsequent conventions, formulated definite rules in this connection. These rules, it is generally recognised, have tended to produce vessels with an internal subdivision which is calculated to ensure the maximum degree of security possible, having in mind at the same time the economical objects in view as represented by the revenue earning capacity of the vessels in the shape of cargo and passenger carrying. Such regulations require the provision of bulkheads at points depending on the nature of the vessel and the conditions under which she is called upon to operate, and it is obviously of fundamental importance that not only the actual bulkhead, but all attachments should be so constructed as to ensure that watertight conditions are maintained under very severe circumstances such as, for instance, the complete flooding of one or more compartments.

It is generally recognised that the piercing of a bulkhead for the continuity of pipe lines leading from one compartment to another impairs very substantially the efficiency of that bulkhead as a watertight division. Normally, in all passenger or cargo vessels a considerable number of pipe lines is necessary, and this involves the piercing of several bulkheads at more than one point. Moreover, such holes are generally at the lower extremity of the bulkhead in the vicinity of the tank top, so that, from the very nature of their position, these holes are at the most dangerous point in the event of flooding. Precautions have certainly to be taken to avert the possibility of water gaining access to intact compartments by way of such pipes in the event of damage, and these sometimes take the form of non-return valves, or screw-down bulkhead valves, but even so it is possible to conceive circumstances under which these measures might not secure that immunity from danger for which they have been provided.

With a view to overcoming such dangers and eliminating the necessity for piercing watertight bulkheads, a modified form of construction, embodying a watertight duct or passage running along the length of the vessel between the inner and outer bottoms has been devised and applied with considerable success in the case of several vessels. This watertight passage, which is of box-section, is disposed at the centre line of the vessel, and all pipe lines associated with such duties as ballast,


5" Suction & Fill.g N.o 3 Tank Wing
3½ Bilge Suction N.o 2 Hold
5" Suct.n & Fill.g N.o 2 T.k Cr P & S.
5" Wing
2½ Bilge Suct.n N.o 1 Hold P & S.
2½ Cofferdam Suction Port
5" Suct.n & Fill.g N.o 1 T.k P & S.
DEEP TANK
N.o 2 HOLD
N.o 1 HOLD
Pipe to Wings Across Above Tank Top.
74 78 82 86 90 94 98 102 106 110 114 118 122 126 130 134 138 142 146 150 152
W.T.B.
Non W.T. Centre
Oiltight Cr Division
N.o 4 Tank (Oil Fuel or W.B.)
Oiltight Cr Divis.n
N.o 3 Tank (Oil Fuel or W.B.)
Oiltight Centre Division
N.o 2 Tank (Oil Fuel or Water Ballast)
Hold Well
Non Oiltight Cr Division
N.o 1 Tank (Oil Fuel or W.B.)
W.T. Cofferdam Non W.T. Centre
3½ Bilge Suct.n
5" Wing Fill.g & Suct.n N.o 3 Tank (Port)
DEEP
3'-0" x 1'-6" Mhole for Ship.g Suct.n Pipes
5" Cr Fill.g & Suct.n N.o 2 Tank (Port)
5" Wing Fill.g & Suct.n N.o 2 Tank (Port)
3½ Hold Well Suct.n
5" Filling & Suction N.o 1 Tank (Port)
2½ Fore P.k Suction.
N.o 4 TANK
D.o (Star.bd)
N.o 2 TANK
D.o
N.o 1 TANK
TANK
D.o (Star.bd)
D.o (Star.bd)
D.o

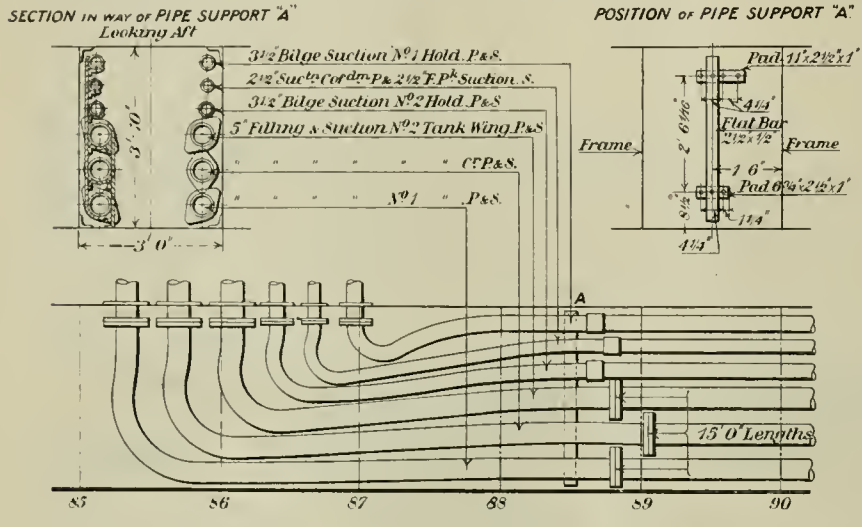
Fore Part of SS. "London Mariner," showing General Arrangement of Duct Keel.

bilge, oil-filling, suction, and heating; fresh water for domestic and feed purposes, &c., are accommodated along the fore and aft sides of the passage-way.

We were recently given an opportunity of inspecting a vessel fitted with this watertight passage-way and were favourably impressed by several of its features. The vessel in question was the *London Mariner*, one of a new type of fast cargo steamers, built by the Furness Shipbuilding Co. Ltd., Haverton Hill-on-Tees, for Furness, Withy & Co. and recently placed in service. This vessel represents one of the finest types of modern high-class freighter and embodies in her construction many novel and up-to-date features. Her principal particulars are as follows—

Length, b.p.	450 ft.
Breadth, o.a.	58 ft.
Depth, mld. to upper deck	31 ft.
Draught	26 ft. 6 in.
Deadweight	9,000 tons.
Speed	13 knots.

In passing, mention should be made of the fact that the vessel is oil-burning and is fitted with Brown-Curtis double-reduction geared turbines of 4,600 s.h.p. We publish on page 479 a photograph taken inside the oiltight duct or keel, and from the drawing which we reproduce on page 477, some indication of the construction may be gathered. We believe that this is the first time a photograph has been taken of a duct keel on a vessel. Apart from the question of the elimination of the necessity for piercing bulkheads, the method of construction under consideration secures several other advantages which are to our mind almost equally important. Primarily, it should be stated that the interior dimensions of the duct are 3 ft. 10 in. vertically, and 3 ft. athwartships. In the case of the *London Mariner* the duct commences under the boiler room and runs forward for a total length of 151 ft., or in other words, from abaft the mid-length of the boiler room to three floor spaces forward of the after bulkhead of No. 1 hold. The method of stowing the pipes is clearly seen in the photograph and in the drawing reproduced below, and in passing along the entire length of the duct, with these pipes *in situ*, we were agreeably surprised at the facility of movement possible, it being a matter of ease to turn completely round from facing forward to facing aft and to operate a spanner, a hammer or such other tools as are likely to be necessary in remaking joints, &c. As may be seen from the end view of the duct in the drawing above, there are in all 12 pipes, namely :—six oil-fuel filling and suction pipes each 5 in. in diameter ; four 3½-in. diam. and two 2½-in. diam. bilge and tank pipes. These pipes are arranged six on each side of the duct and have easy bends where they turn to enter the tanks and holds. In the foreground of the photograph, the oil-fuel suction and filling pipes may be seen, and those run up through the roof of the duct to the oil-fuel suction and delivery chest. Behind these are the bilge pipes to the forward holds and the suction to the forepeak. In the case of the oil-fuel pipes, hydraulic-wing gauges, fitted with only two bolts, have been used as this greatly facilitates stowage. The pipes are arranged in long lengths, and these were inserted by way of the large manhole shown in the upper foreground of the photograph after the tanks had been tested. As the duct keel forms a strength member in the structure of the ship, the scantlings are of some interest. The sides of the duct are of the same poundage as the adjacent watertight or oiltight floors, and the gutter plate is to Lloyd's rules. The top and bottom angles are 3½ in. × 3½ in. and are single riveted. In the case of the flat-keel plate, double thickness of 1-in. plating has been used, although Lloyd's requirements call only for ⅛ in. in excess of rule thickness.



Detail Drawing showing Arrangement of Pipes in Duct Keel.

Among the advantages claimed for this form of construction a great feature is that the bilge and other pipes are located in a perfectly accessible compartment clear of all cargo space. This not only protects the pipes from damage by cargo, but also eliminates the necessity for piercing bulkheads, as we have already pointed out, and does away with large numbers of expansion bends. The cargo itself is protected from damage from leaky pipes, whether such leaks be due to the straining of the ship in a seaway, or to leakage of water from the fore-peak tank into a hold, or form one compartment to another. Tank suction pipes can be led through the duct keel in such a manner that the whole of the double-bottom compartments on either side and at the end of the duct are properly served without there being any difficulty in attending to these pipes should they require repair at any time. A sounding pipe is led to the duct so that, if necessary, soundings may be taken when desired. It is claimed that the construction of the duct is such that it affords considerable additional longitudinal and vertical strength to the vessel without detracting in any way from the transverse strength. This particular point was the subject of considerable controversy when the proposal was first put forward, but the question of strength has been thoroughly investiagted by the principal registration societies and that it has been found satisfactory may be assumed from the fact that the design and scantlings carry the highest classification of Lloyd's.

It is also claimed that the cost of building is reduced, owing to the fact that the weight of steel in the double bottom is appreciably less, while there is no need for pipe protection in the holds and the piping systems are much straighter and have fewer joints. In the case of an insulated ship, the difficulty of supplying heat to oil-fuel tanks is practically overcome by leading the pipes along the duct. Up to the present, 15 vessels have been fitted with the duct keel, and it is understood that the results achieved on service have been of a highly satisfactory nature. We also learn that the duct keel has been adopted by the Orient Steam Navigation Company for the two 20,000 ton vessels they have recently ordered, one from Vickers' and one from John Brown & Co. Ltd.

THE MARINE AND SMALL CRAFT EXHIBITION.

The Marine and Small Craft Exhibition, which was held at the Agricultural Hall, Islington, from November 14 to November 24, was, as its name implies, a purely small craft show, and, as such, undoubtedly proved itself interesting to visitors and served its purpose well. The sailing boat builders and the builders of racing skiffs, punts, canoes and other river craft received full opportunity to display their products, and the result certainly did them credit.

The motor exhibits included many different types and ranged form 60 h.p. down to about 1 h.p. Among the exhibitors were the following firms :—Aeromotors Limited ; Bergius Launch & Engine Co. Limited ; Bruntons (Sudbury, 1919) Limited ; Comet Marine Motor Company ; A. E. de Lacey & Co. ; James T. Donald & Co. ; Evinrude Motor Company ; Reed's Patent Engine Company Limited ; Safix Marine Engine Company Limited, and George Spicer. Considerable interest was shown in the 26-ft. launch exhibited by the Hotchkiss Hydraulic Propeller Company. This craft has a beam of 4 ft., a draught of 6 in. when loaded with six persons and the propelling unit gives it a speed of 7½ m.p.h.

INSTITUTE OF PATENTEES.

A Plea for the Protection and Encouragement of Inventors.

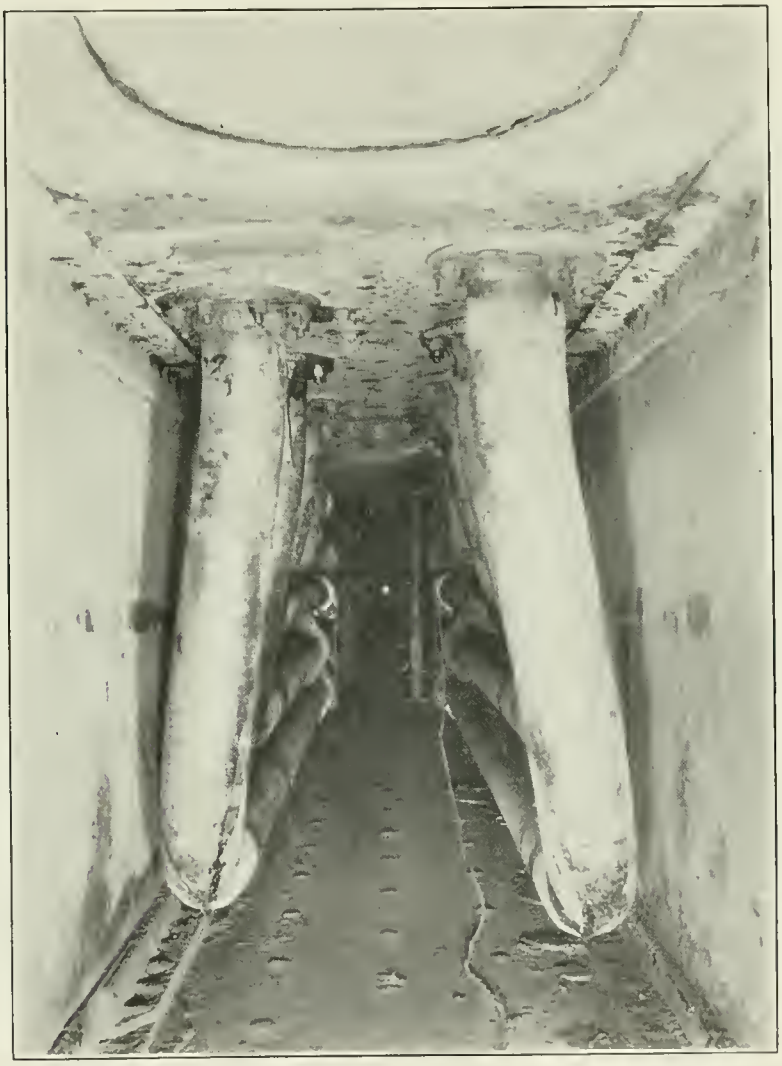
We have received the following letter from Sir William Grey-Wilson, K.C.M.G., K.B.E., Chairman of the Administrative Committee; Professor A. M. Low, D.Sc., and Godfrey Cheesman, Esq., F.R.G.S., Members of the Executive Council of the Institute of Patentees.

"We have for some considerable time noted with great interest the manner in which you have encouraged scientific progress.

"The most successful ideas have often humble beginnings, and in this connection it is important to note that the patentee in England has to contend with many serious difficulties. In America, by one single payment of £7, a number of years' complete protection is assured, after a search which is so comprehensive as almost to guarantee validity.

"We do not think many of your readers are aware of the existence of this society, the one object of which is the protection of the inventor. It has been organised for a little over a year, and it has no self-seeking motives. The whole scheme is to protect the result of the work of its members and to assist them to meet with likely manufacturers. The Institute of Patentees is affiliated to the National Union of Manufacturers, itself a very important and active organisation. It has been a source of great surprise to us that such a society is not better known. The entrance fee for full membership is £3 3s., and the annual subscription is £2 2s. There is no entrance fee for associate membership, only an annual subscription of £1 1s. The supporters of the Institute can send up patents, and they can receive reports upon them from men who are absolute experts in different branches.

"We must make it clear that the services of the officials of this Institute are given absolutely for nothing, the whole point being that if a large membership is attained, as will undoubtedly be the case before long, their strength by united effort will be enormous.



Photograph taken in the Duct Keel of the "London Mariner," showing Arrangement of Pipes. (*See page* 477.)

"The Institute now has a membership approaching 1,000.

"Considerable progress has been made towards alleviating the many difficulties under which the inventor labours. The great expense of taking out patents throughout the world is being taken up with the Controller of the British Patent Office, and already many inventors have cause to bless the Institute for their good offices in bringing them into touch with the right financial group.

"It is, perhaps, necessary to point out that the Institute in no way clashes with the patent agent; very much the reverse, because the first thing that is done is to instruct the inventor to apply to any good patent agent, and afterwards the Institute, if the particular invention is approved by the Council as being of some use, will work hand-in-hand with the inventor and will really give him practical help.

"There is no doubt that such a body when it becomes better known, will be to the patentee what the R.A.C. and A.A. have been to the motorist for many years.

"The Organising Secretary is Captain G. Drury Coleman, of 44, Great Russell Street, W.C.1, and we do not hesitate to approach you with this information, knowing that the Institute of Patentees is not a commercial body, but purely what we might term a 'mutual protection society.'"

Death of Former Lloyd's Surveyor.—The death has taken place at West Kilbride, Ayrshire, of Mr. Thomas J. Dodd, formerly and for many years principal shipbuilding surveyor of Lloyd's Register, Glasgow, and well known in Clyde shipbuilding and shipping circles. He was born at Portsmouth in 1847, and his early training was acquired in Government establishments. In May, 1873, he was appointed to Lloyd's Register of Shipping as surveyor, and in February, 1880, he joined the Society's staff at Glasgow, and was promoted to the post of principal surveyor for the Glasgow district in November, 1889.

DIESEL-ELECTRIC SHIP "PELIKAAN."

The *Pelikaan*, an illustration of the engine room of which is shown below, is a mothership for submarines for service in the Netherlands East Indies. The vessel was built by the Netherland Shipbuilding Company, Amsterdam, and engined by the "De Schelde" Shipbuilding & Engineering Company, Flushing.

The principal dimensions of the *Pelikaan* are :—

Length, overall	307 ft. 2 in.
Breadth	42 ft. 7 in.
Depth	27 ft. 2 in.
Draught	13 ft. 2 in.

As a considerable amount of repair work has to be carried out on the vessel, a well-equipped workshop is installed and also storage sufficient for the running stores required for six submarines. The oxygen store contains a battery of 24 cylinders of oxygen, the contents of which can be pumped into the oxygen cylinders on board a vessel lying alongside. This store also contains 78 cylinders of carbonic acid gas. On the upper deck of the vessel is a hangar for two seaplanes which are handled by an electric winch and a derrick attached to the main mast. In this compartment the tanks for petrol and oil for the 'planes and the motor boats are fitted. A battery of cylinders of carbonic acid gas is fitted immediately beneath the hangar to which there is a connection, so that the compartment can be filled with gas in case of fire.

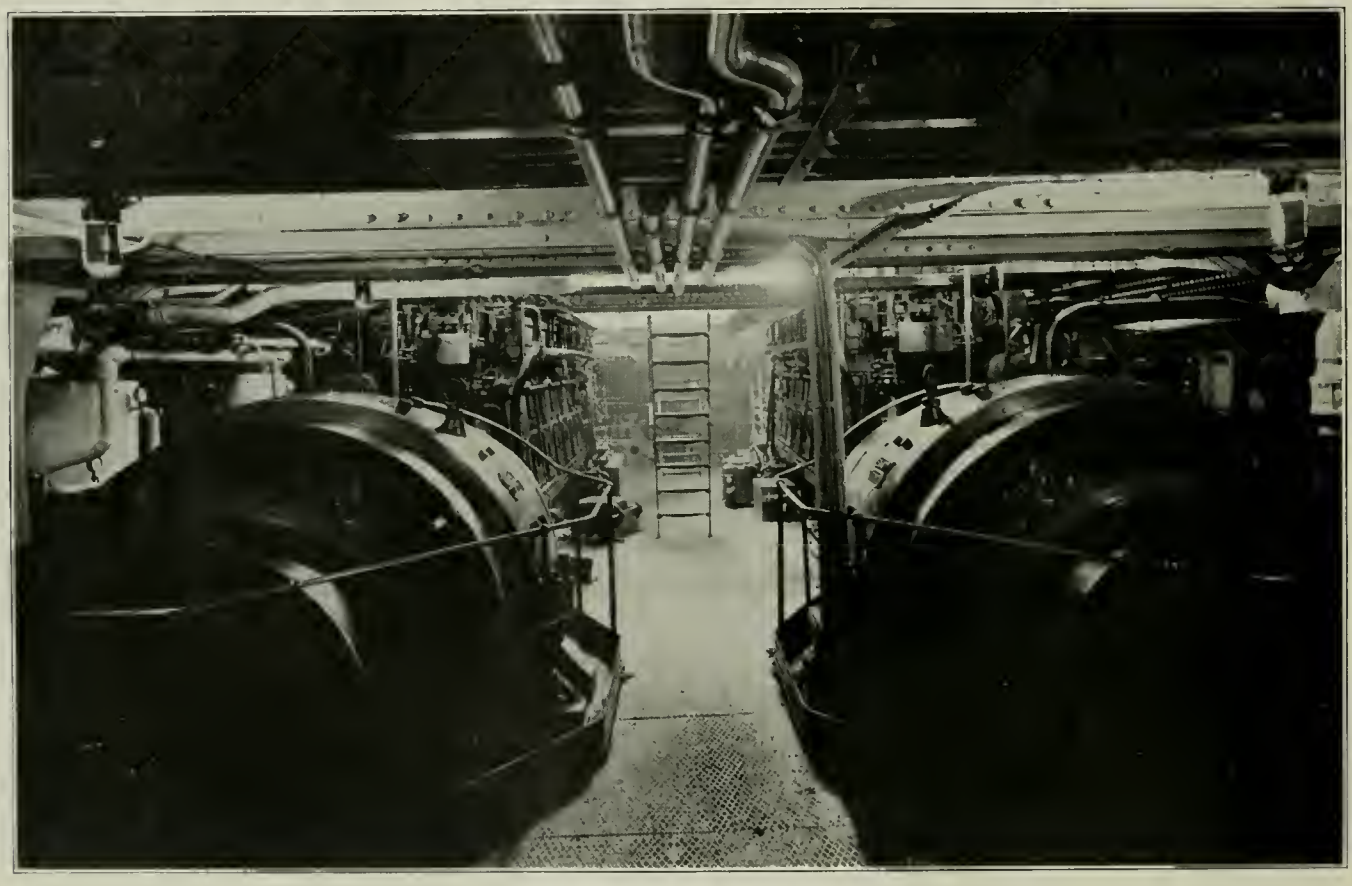
The *Pelikaan* has two complete refrigerating plants which are used for the refrigerated stores and magazine cooling.

The particular form of stem fitted to the vessel has been adopted as it serves for hoisting loads up to 10 tons. The deck machinery is electrically driven and includes a winch fitted on the bridge deck at the foremast, a boat winch at the main mast, two windlasses on the upper deck and one on the forecastle. The steering gear is of the electro-hydraulic type controlled by telemotor.

The armament of the vessel consists of four machine guns and four 7·5 cm. anti-aircraft guns. Each mast is fitted with a searchlight.

Machinery.

The propelling machinery of the *Pelikaan* is of the Diesel-electric type. The Maschinenfabrik Augsburg-Nurnberg supplied the Diesel engines and the Electrotechnische Industrie, Slikkerveer, the main motors. Each of the two 700 h.p.



Engine Room of the "Pelikaan" showing the M.A.N. Diesel Engines and the Main Generators.

Diesel engines has six cylinders and drives a continuous-current dynamo of 468 kw. 1,200 amps. 390 volts, which supply current to the main motors, the torpedo air pumps and for charging submarine batteries. The continuous current propelling motors are of 570 s.h.p., 380 volts, 1,200 amps. at 190 r.p.m., and each drives a three-bladed propeller. The wiring is so arranged that each dynamo can drive either motor and can also drive both motors simultaneously. The main switchboard is installed in the engine room on the port side. For driving the winches, the steering gear motor, the motors in the repairing shop, the converters and for lighting, two compound continuous-current dynamos of 32 kw. 220 volts and 145 amps. are fitted in the engine room, coupled to a 50 h.p. Diesel generator. On the awning deck a dynamo is installed driven by a 25 h.p. Kromhout motor, as a spare installation for emergency lighting and for driving the boat winch.

APPROXIMATE TRIM FORMULÆ.

By E. V. TELFER, M.Sc.

Many formulæ exist for the approximate determination of the moment to change trim one inch of ships. Some of these formulæ are based upon sound first principles and may be simply deduced from an elementary consideration of the simple principles of longitudinal stability. Others, however, are totally empirical, being expressed in terms of variables which have no immediate relation to the subject but which, for a given ship type, may have yielded apparently accurate results. Approximate formulæ, once their validity has been established, are exceedingly useful in design and routine calculation work. It will be profitable, therefore, to examine the basis of existing successful formulæ in order to determine which of them offers the greatest probability of accuracy and simplicity.

The fundamental expression for the moment to change trim one inch is of course—

$$M = \frac{\Delta.(R - a)}{12\,L} \quad \ldots\ldots(1)$$

where Δ = displacement in tons.
R = Longitudinal metacentric radius in feet.
a = Vertical separation of centres of buoyancy and gravity, in feet.
L = Length of vessel, in feet.

For all practical purposes this expression may be written—

$$M = \frac{\Delta\,.\,R}{12\,L} \quad \ldots\ldots(1a)$$

the longitudinal metacentric height being considered equal to the metacentric radius. In this expression the only unknown is R. which, of course, equals $\frac{I}{\nabla}$, and which, in turn, may be expressed as—

$$R = \frac{I}{\nabla} = \frac{f(\alpha)\ L^3.B}{L.B.T.\delta} = \frac{f(\alpha)}{\delta}\ \frac{L^2}{T} \quad \ldots\ldots(2)$$

in which—
I = Longitudinal moment of inertia.
∇ = Volume displacement in cubic feet.
α = Waterplane area coefficient.
$f(\alpha)$ = Waterplane inertia coefficient.
T = Draft, in feet.
δ = Block coefficient.

substituting the above value of R in (1a) we have

$$M = \left(\frac{L.B.T.\delta}{35}\right) \times \frac{f(\alpha)}{\delta}\ \frac{L^2}{T} \times \frac{1}{12\,L}$$

$$= \frac{f(\alpha)}{420} \times L^2.B \quad \ldots\ldots(3)$$

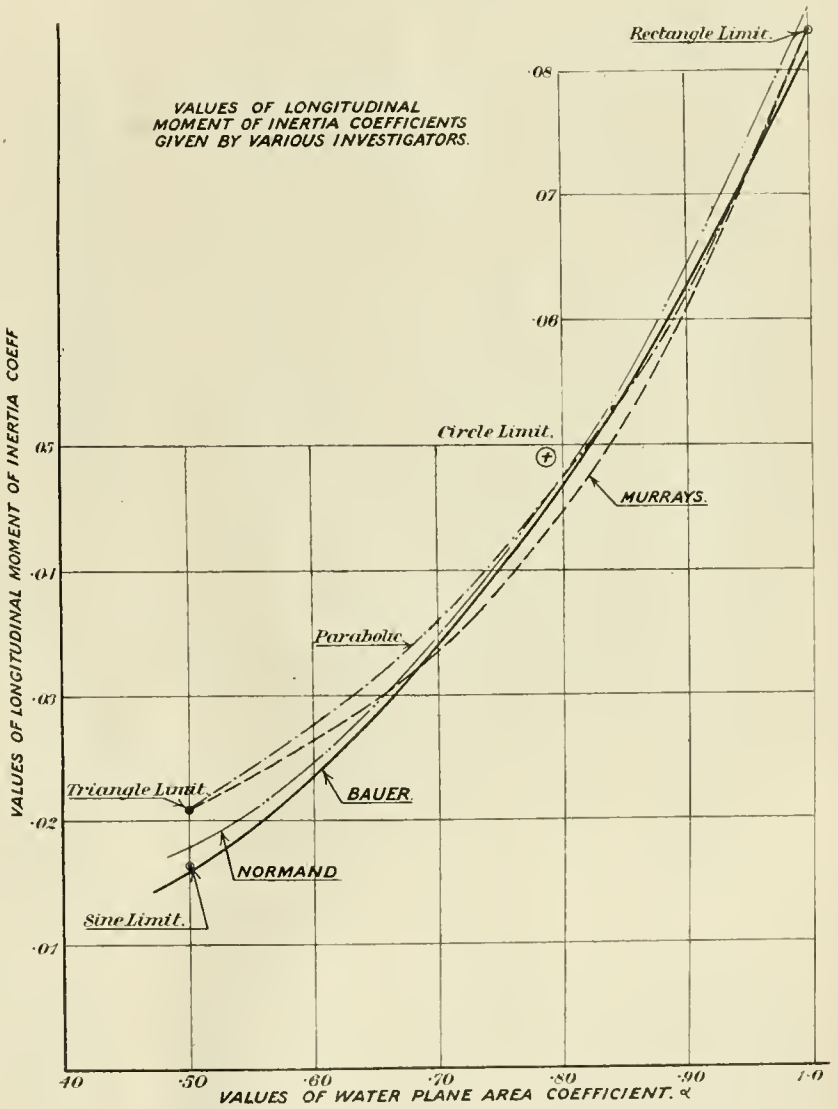


Fig. 1.—Longitudinal Moment of Inertia Coefficients.

Various expressions have been proposed for $f(\alpha)$ and the more important and reliable of these are grouped in the table on page 483 and plotted to a base of α in Fig. 1.

To review the merits of these formulæ, the form of ship's waterplane may be imagined to vary between a rectangle of area coefficient unity and a sinusoidal figure of area coefficient ·50. The values of $f(\alpha)$ corresponding to these particular limits are ·0833 and ·01634 respectively, and thus any expression for $f(\alpha)$ should conform to these limits. An intermediate geometrical limit, which is also of service, is that of an elliptical waterplane whose area coefficient is ·7854 and whose inertia coefficient is ·0491. This limit will be an obviously superior limit because the end concentration of area with this form is very rarely met with in practice.

Examining first the Normand expression, proposed as long ago as 1863, we find that the upper and lower limits are slightly exceeded, but the medium limit is not too closely approached. The Normand curve, therefore, may be expected to lie slightly above current practice, and generally this is actually the case. This excess was evident to Bauer, and in his expression, which was published in 1903, and which was based upon an analysis of modern vessels, a better agreement with current practice is obtained. The Normand formula was based upon early French warship forms, evidently of fine midship section and relatively full ends. However, the actual difference between the Normand and the Bauer formulæ over the practical range of area coefficient of ·70 to ·90 is very small. The Bauer expression gives a curve which lies slightly

below the upper and lower limits, but as already mentioned, agrees exceedingly well with modern practice. The Murray formula, which was first published about 1908, has as its basis the substitution for the actual waterplane of a trapezoid of equivalent area. This expression will thus have the lower limit a triangle and the upper limit a rectangle. The trapezoidal substitution for forms in which no hollow exists will involve too great a concentration of area amidships, thus resulting in too small a longitudinal moment of inertia and too great a transverse. This latter point may be gathered from Mr. Murray's letter to the *Marine Engineer and Naval Architect*, April, 1922, p. 160. Thus, for very fine forms, the Murray expression will produce too high a result, whilst for medium and full forms the reverse will be the case. The parabolic formula given here (it is believed) for the first time has as its basis the substitution, for the actual waterplane, of a parabola of equivalent area. The formula is analogous to that proposed by Olsen and Ornell, referred to in the first portion of the present writer's article on "The Transverse Metacentric Height of Ships" in the January, 1922, number of the *Marine Engineer and Naval Architect*. From Fig. 3 of that article it is seen that the parabolic formula gives too low a result. The corresponding formula for longitudinal inertia can therefore be expected to give too high a result, since the parabolic form evidently involves too great a disposition of area towards the ends. Over a practical range it will be found that the parabolic and trapezoidal curves enclose all normal types of form, actual spots being almost invariably nearer to the parabolic than to the trapezoidal. In fact, over this range, the parabolic gives quite accurate results. Its limits are of course identical with the trapezoidal. Of the four expressions examined it is probably the simplest as far as arithmetical simplicity is concerned, and for ordinary work is to be recommended. Whilst simplicity of calculation is always desirable, this, of course, should not be at the expense of accuracy. The most accurate of the above expressions is the Bauer, and which, although slightly more complicated arithmetically than the parabolic, can be made as simple as any by nomographic representation. This has been done in Fig. 2, and the Bauer expression—

$$M = \frac{(5{\cdot}55\alpha + 1)^3}{20{,}730} \cdot L^2.B$$

is there given in a form which is probably the most convenient for designers. An example illustrating the use of this chart is shown on it. The length and breadth values are first connected, and through the resulting intersection with the support line, a line is drawn from the waterplane coefficient valve, which line intersects the moment scale at the required value. The actual example refers to a vessel of length 436 ft., beam 53 ft., $\alpha = {\cdot}879$. The actual moment to change trim was 1,460 ft./tons, and from the chart a value of 1,450 ft./tons is obtained. This accuracy, it will be admitted, is all that is required in practice.

In the deduction of all the above formulæ the waterplane centroid has been assumed to be amidships. Bauer has investigated the effect of this assumption and has published formulæ which take into account the different fullnesses of fore and after bodies. For all normal cases, however, the positon of the waterplane centroid has but little effect upon the metacentric radius, and hence upon the value of the moment to change trim one inch.

In the foregoing only the more reliable and more general formulæ have been examined. Many other formulæ of course exist, but it is suggested that the generality of those examined, and the simplicity of the nomographic representation of that finally selected, should render the examination of further formulæ unnecessary, however desirable this further examination may be from the point of view of historical survey and completeness.

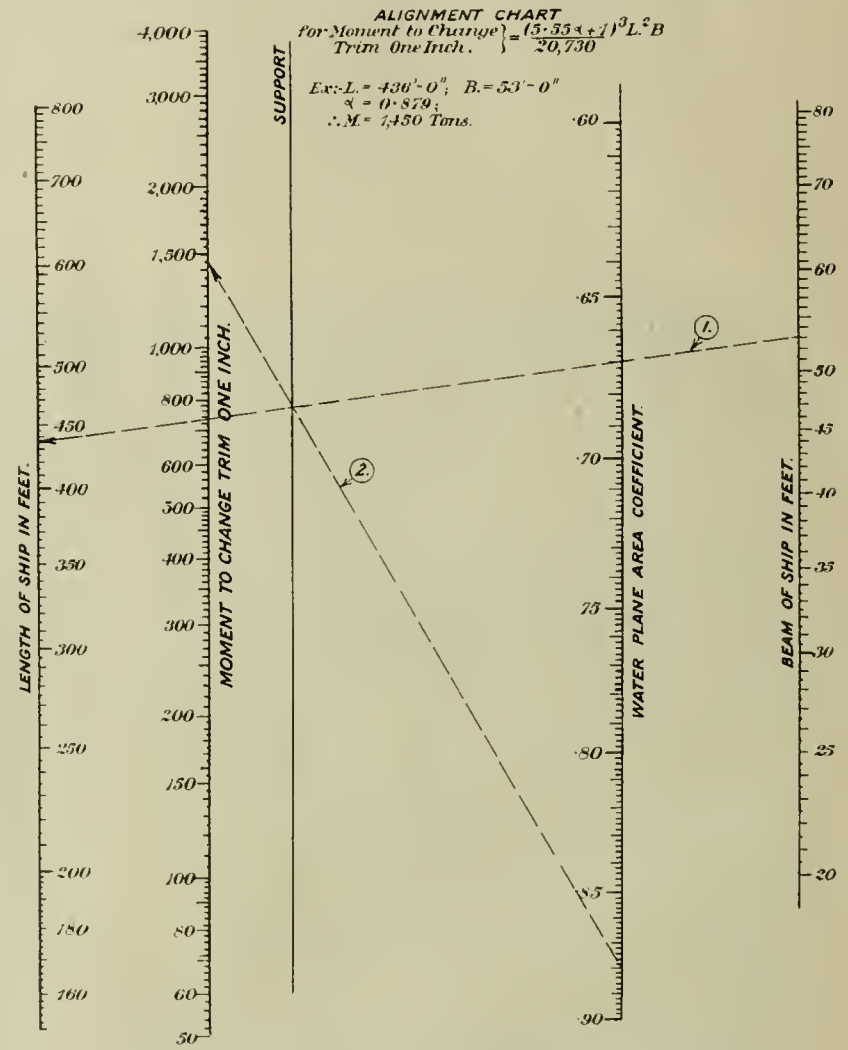

ALIGNMENT CHART
for Moment to Change Trim One Inch. = (5·55α + 1)³L².B / 20,730
Ex:-L.= 436'-0"; B.= 53'-0"
α = 0·879;
∴M.= 1,450 Tons.
SUPPORT
LENGTH OF SHIP IN FEET.
MOMENT TO CHANGE TRIM ONE INCH.
WATER PLANE AREA COEFFICIENT.
BEAM OF SHIP IN FEET.
1.
2.

Fig. 2.—Alignment Chart for Determining Moment to Change of Trim.

TABLE OF INERTIA COEFFICIENTS.

Investigator or Method.	Inertia Coefficient $f(\alpha)$.	Basis.	Reference.
Normand	$\cdot 008 - \cdot 077\alpha^3$	Warship Data.	"Formules approx. de Construction Navale." 1863.
Bauer	$\frac{(5{\cdot}55\alpha + 1)^3}{3450}$	Merchant Ship Data.	Johow-Foerster, Hilfsbuch für den Schiffbau, 1920: p. 244.
Murray	$\frac{\alpha - 2\alpha^2 + 2\alpha^3}{12}$	Analysis. (Trapezoid basis.)	*Marine Engineer & Naval Architect*. April, 1922. p. 160.
Parabolic	$\frac{\alpha}{12(3 - 2\alpha)}$	Analysis. (Parabola basis.)	—

T.S.M.S. "ADDA."

New Passenger and Cargo Liner for Elder, Dempster & Co.

The new Elder, Dempster twin-screw motor passenger and cargo liner *Adda* ran trials on the Clyde on November 14 and sailed from Liverpool on her maiden voyage on November 29. This ship is the second motor liner of the fleet, the first, the *Aba*, having been put on service about 12 months ago. She has proved very successful and the owners have been induced to go a step further in the new vessel. The *Adda* has been built by Harland & Wolff Limited at their Greenock shipyard. She has the following dimensions :—

Length	450 ft.
Breadth	57 ft.
Moulded depth to awning deck	34 ft. 6 in.
Tonnage	7,800 gross.

The vessel has a displacement of approximately 12,800 tons, and will be one of the largest liners in the service. She will maintain a service speed of about 14 knots. Accommodation has been provided for 225 first, 74 second and 32 third-class passengers.

The propelling machinery consists of two 8-cylinder 4-cycle Diesel oil engines of Harland & Wolff's standard type of the well-known Burmeister & Wain system, and the engines develop a normal horse-power of 6,000 i.h.p. at 115 r.p.m. Compressed air for fuel injection is provided from three-stage air compressors, mounted in tandem at the forward end of each engine, and driven off an extension of the crank-shaft. The engines have forced lubrication throughout, and the cylinder jackets and cross-heads guides are cooled by sea water, fresh water being used for piston cooling. The air for manœuvring purposes is stored in three reservoirs at 26 atmospheres, the former being charged by two three-stage electrically-driven air compressors.

The *Adda* carries sufficient oil in her double bottom, and also in deep tanks abaft the motor room, to enable her to make a round trip to West Africa and back without refilling *en route*. The double bottom extends right forward and aft. About 820 tons of oil is carried, and this quantity can be taken aboard, under favourable circumstances, in about five hours.

Electro-vapour radiators are fitted throughout all classes of accommodation and also in the crew's rooms. Practically every function in the ship is performed by electricity. Windlass, cargo winches, steering gear, which is of the Harland & Wolff design, all engine room auxiliaries, fans, galley appliances, laundry appurtenances, &c., are driven by electric motors.

The cooking ranges in the galleys are oil-fired, and the grills, &c., are electrically heated. Potato-peelers, dish-washers, dough-mixers, &c., are all electrically driven.

The electric installation is on the double-wired system, and lead covered wiring is used throughout, except in those positions liable to exposure when steel-armoured cables are used. There are approximately 60 miles of electric wiring and cable in the ship.

The insulated cargo and stores space is situated in No. 3 hold. The spaces for insulated cargo and that allocated for ship's stores use, are divided by a short orlop deck. There are separate cold chambers for poultry, meat, fish, and fruit. The refrigerating machinery is by J. & E. Hall Limited, and is driven by Laurence-Scott motors.

The *Adda* carries about 5,000 tons of cargo. She has 12 cargo winches all electrically driven. They are of the latest Laurence-Scott type, and are capable of dealing with loads up to 4 tons. There is also a powerful warping winch, with large drum ends, which can be used as an emergency steering gear. The derrick gear consists of 20 channel derricks for lifts up to 10 tons.

Clay's automatic steering control is fitted to the pedestal in the wheelhouse, thus precluding the helm orders transmitted by the officers from any possible error in execution. A complete installation of Kelvin, Bottomley & Baird's pneumercators permits of the exact drafts of the vessel being read direct from the chart room. There is also an installation of "Bonlow" tank gauges enabling the capacities of the double bottom and deep tanks to be read direct from the engine room. The temperatures of the cold chambers can also be read from the engine room by means of the "Sentinel" long-distance thermometers.

SUPPORTING PINION BLANKS.

A correspondent writes :—"Much has been done to obtain accurate gears, and not the least of the efforts of manufacturers has been to measure the accuracy of each tooth to within a fraction of a mil. When such accuracy is aimed at it may be worth while to consider a little more closely the methods employed in gear cutting, especially with reference to the pinion. The wear of the hob or cutter has been blamed for the variations of the tooth dimensions of the finished pinion, and no doubt this is to a certain degree responsible. It appears, however, that in cutting the teeth, sufficient precaution is not always taken to prevent the pinion from bending during the process. If the pinion is supported at the journals, and the hobbing system is employed, the pinion may be regarded as a beam with a load (due to the cutting action of the hob) moving from one end to the other. From this analogy it would appear that the bending moment acting on the pinion will change from a minimum at the end to a maximum at the middle, changing again to a minimum at the other end as the load moves along. But this would be only half the case for the reduction of the sectional area of the "pinion beam" due to the cutting process would result in making the pinion less and less rigid to bending as the cutter moved along. The effect of course would vary, depending upon whether the cut commenced at the middle or at the end. The result of such an operation therefore would be a 15 per cent. variation of accuracy of tooth form and helical angle from one end of the pinion to the other. If, on the other hand, the teeth of the pinion were cut by the planing process, the result would be rather different. In this case the first tooth cut would be more or less accurate, while the last tooth cut would present variations owing to the decreased rigidity occasioned by the cutting of each successive tooth, or, to put it in other words, the teeth would vary in accuracy circumferentially and axially, while with the hobbed pinion the variations would manifest themselves axially only. How far the difference in results of the two methods of tooth cutting is borne out in practice it is difficult to say, but it would be interesting to know what, if any, diversity there is. But whether or not the effect above referred to is purely theoretical and without foundation in fact, it appears that, for all the extra expense involved in fitting such an attachment to the gear-cutting machine, there is every justification for giving a good, solid support to the pinion along its whole length during the cutting process instead of allowing the pinion to bend between the end supports as is the present practice."

DUMB BARGE RUDDER DESIGN—A REPLY TO "WATERWAY."

To The Editor of

The Marine Engineer and Naval Architect.

I have read with interest the reply of your correspondent "Waterway" to my criticism of his October article on "Dumb Barge Rudder Design."

Your correspondent now states that rudder shape was not discussed in his article, but if he refers once more to page 350, he will find that the first column deals almost entirely with this aspect of the subject, the sniping away of the rudder at its lower edge being merely one point of his remarks. In his original article your correspondent made the statement (which I took exception to) that "Considering canal craft, there appears to be considerable divergence of opinion regarding the shape which the rudder should assume . . ."—and now, in his reply to my criticism, he states "It is universally agreed that for the type of craft under discussion the approximately rectangular rudder is most suitable and efficient." I am thus glad that in at least one point your correspondent apparently admits the justification of my criticism.

I regret that your correspondent insists upon the inefficiency of the keel portion of barge rudders. The crux of the controversy lies in your correspondent's non-appreciation of the magnitude of wake. Precise data on the wake of barges I admit is scarce, but data on full merchant ships is available and can be of service as far as the wake at the surface is concerned. The keel wake will be altered by the depth of clear water, but this will be discussed later. In Mr. Baker's book "Ship Form, Resistance and Screw Propulsion," p. 191, a description of Calvert's classical experiments on wake are given. The Calvert model had a block coefficient of 0·64 and yet the wake at the surface was 64 per cent. Similarly in Walker & Cook's 1921 Institute of Naval Architects' paper, in which the wake distribution of the *San Fernando* was given, a value of 62·7 per cent. was obtained at about half a propeller diameter below the surface. In both these cases no propeller was attached to the model. Thus, as far as surface work is concerned, I think your correspondent should acknowledge that he has somewhat underestimated its magnitude in the case of barges. With regard to keel wake it is first necessary to emphasise that all the remarks made in my previous letter apply with even greater force to estuary craft than to canal craft. (See Baker, *ibid.*, Chapter XV.) I am sorry that your correspondent cannot appreciate the generality of the Venturi meter analogy mentioned in my previous letter. However, probably he has heard that in estuaries vessels must slow down when crossing the bar. Vessels whose keels were apparently two or three ft. clear of the bar have been often known to strike it when their normal speed has been maintained. This could only have been caused through a sinkage of the vessel brought about by the reduction in the supporting force of the contiguous water consequent upon the increase of the stream line velocity round the vessel's bottom. It is very important to remember that a vessel's weight is only supported by the vertical component of water pressure. With a box-shaped vessel the vertical sides offer no support to the vessel, and hence any change in the intensity of pressure brought about by the velocity of water past the ship's sides will produce no sinkage of the vessel. With slightly rounded sides some sinkage will take place, but not sufficient to account for actually observed amounts. There can be thus no doubt that actual sinkages can only be explained by the reduction of pressure on the vessel's bottom brought about by the relatively high stream velocity in this vicinity. If your correspondent will accept this explanation of a very common and well-known phenomenon, then as a corollary he, perhaps, will agree that the universal practice of placing as much of the rudder area as possible at the keel has at least some plausible justification.

Next as to your correspondent's defence of his use of Beaufoy's formula. Apart from the technical sin of using formulæ placidly and without question because they err on the side of safety, your correspondent has a little to learn with regard to the validity of the Beaufoy formula. Mr. A. W. Johns has shown that the value of the constant 1·12 is roughly only half what it should be when Beaufoy's own results are carefully analysed. This makes one hole in your correspondent's side of safety. Where the safety aspect does arise, is due to the high estimate of speed adopted by your correspondent. Unfortunately, your correspondent in endeavouring to be on the safe side also finds himself well on the side of ignorance and absurdity. To substantiate this statement, consider your correspondent's formula for the length of tiller given on p. 352. Here $l = 0{\cdot}024\ A\ v^2\ D$. Your correspondent insists in his letter that speeds up to 5 to 10 m.p.h. must be provided against. Thus, with 10 m.p.h. v equals $\frac{5280}{3600} \times 10 = 14{\cdot}67$ ft. per sec. From the detail rudder sketch given on p. 350 this rudder seems to be approximately 5 ft. long by 2 ft. 6 in. deep. Thus the area equals 12·5 sq. ft. and the centre of pressure lever equals, say, 2 ft. Thus assuming, with your correspondent, a wake of 6 per cent., the relative velocity at the rudder equals $14{\cdot}67 \times 0{\cdot}94 = 13{\cdot}8$ ft. per sec. Therefore, substituting these values in the above expression for tiller length, we have

$$l = 0{\cdot}024 \times 12{\cdot}5 \times 13{\cdot}8^2 \times 2$$
$$= 114 \text{ ft.}$$

With a tiller 114 ft. in length, a combination tiller and bowsprit could be quite easily effected. Allowing for the error in the Beaufoy constant, and assuming a practical length of tiller of 10 ft., it can be simply shown that a wake factor of 80 per cent. will restore an aspect of technical respectability to the problem. This investigation will show how little your correspondent's remaining formulæ may be relied upon. And now finally as to your correspondent's assertion that I suggested leaving the design of the rudder arms to chance. What I did state and maintain is that your correspondent goes to unnecessary length in his method of rudder arm design. He must surely admit that if he has already determined the twisting moment on the stock, that this twisting moment must necessarily equal the sum of the bending moments on each arm as these merge into the stock. Thus the maximum scantling of the arm is simply determined. As to the minimum scantling, I pointed out that considerations of riveting the arm to the plate produced a scantling which was unquestionably in excess of that required from ordinary considerations of provision against bending. Between the maximum and minimum scantling any convenient uniform taper can be adopted. However, your correspondent's method is not without interest and has its lessons. Consider the diagram giving section modulus of arm on a base of arm thickness on page 353. The diagram is merely qualitative admittedly, but surely one is fully justified in concluding from this figure that as the section modulus is greatest when the arm thickness is zero, then arms apparently serve no useful purpose.

I am sorry to have thus trespassed a second time at some length upon your valuable space, but as the views of your correspondent "Waterway" are such as may mislead some of your younger readers I trust that my criticism will at least serve some useful purpose. All I now ask of "Waterway" is that, in his second reply, he will at least endeavour to substantiate any counter-criticism he may wish to make.

"Gouvernail."

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Ship Form.

Treated from the aspect of the practical ship designer, this article is an interesting combination of the practical and the technical. First, a general discussion of form and its usual parameters and coefficients is given. Next, the early technical development of last century is reviewed, commencing with the work of Scott Russell and culminating in the work of William Froude in 1870. Next, the general subject of experiment tanks, their equipment, methods and possibilities are considered. The lessons of the tank for the ship designer form the chief part of the article, and adopting the prismatic coefficient and the prismatic curve of areas as a criterion, the work of Hogg, Baker, Taylor, Sadler, Kent, Bauer and Schaffran is very carefully examined and compared. The effect of centre of buoyancy position is mentioned and also the relative superiority of V- and U-shaped after sections. The author quotes the usual sources of information in this connection, but wisely emphasises the fact that practically all data on shape of section only refer to ships without screws. Reference is made to Schaffran's 521 model series, in which, with the same forebody, three different afterbodies were tried, these being respectively V-, U- and medium-shaped. At 10 knots, without screws the medium- and V-shaped E.H.P.'s were equal, and the U-shaped 13 per cent. higher. At 10½ knots the medium was the best, the U-shaped being 2 per cent. higher. For the same models with screw attached at 10 knots, the U-shaped had 12 per cent. more S.H.P., and the V-shaped 2 per cent. less than the medium ship. At 10½ knots, the U-shaped had 13 per cent. more, and the V-shaped 5 per cent. less than the medium ship. This example brings out very forcibly the danger of drawing conclusions from insufficient premises. The remainder of the article deals with the question of midship section coefficient, and finally the author expresses the wish that Holland may soon possess a well equipped experiment tank, in order that it may contribute its share towards the solution of the problem of ship propulsion.—*Prof. N. Knal, De Ingenieur*, November 11, 1921, p. 909 ; 3 pp.

Propeller Similarity and Experiment.

Model experimental results on propellers are usually restricted in application to the prediction of the performance of larger propellers which are geometrically similar to the model. In this article the author develops the idea of partial similarity in which a larger propeller is produced from a smaller model by having different scale ratios in the axial and radial directions. The results of Schaffran's "A" series of model experiments, in which the projected area was kept constant whilst the pitch was varied, may be considered as a partially similar series. The author next investigates mathematically the similarity of thrust and torque with this type of variation and then examines Schaffran's results in the light of this theory, and shows that reasonable agreement is obtained. In the examination of this data the author makes use of some very interesting methods. It is well known that the torque and thrust constants are functions of the slip ratio. When the slip ratio for a particular propeller's curves of thrust and torque is examined between these variables, and torque is plotted on a base of thrust, the resulting line is nearly straight, and for zero thrust a positive torque is obtained. The torque corresponds to that absorbed in overcoming frictional resistance. This torque varies with the nature of the surface and McEntee's results on propellers of different surface natures support the contention. The method makes it possible to allow for the smaller relative frictional resistance of a full-size propeller, as compared with that of a small model. Many other interesting facts are brought out in the article and many of the present obscure points upon which further experiment would be very desirable are touched upon. These latter embrace such points as the better correlation of the "open" and "behind ship" conditions, the examination of frictional resistance and the origin, causes and elimination of cavitation.—*C. von den Steinen, Werft, Reederei Hafen*, November 7, 1922, p. 671 ; 10 pp. ; 14 ff.

Ships' Officers and Ship Stability.

The present development of ship type and construction is making it imperative that ship captains should be fully conversant with the technique and practice of securing adequate stability. Heavier and higher superstructures and the gradual diminution of engine and fuel weight are necessitating either broader ships or more careful handling of otherwise normal vessels. Captains have for years struggled with the technique of astronomical observations and measurements, and thus there seems but little justification for the present opinion that stability is too technical a subject for the captain. The author, therefore, outlines a method whereby the officer has to carry out an inclining experiment at the commencement of each voyage. The inclining weight consists of a tank of water situated high up on one side of the ship. The observed inclination for a given quantity of water enables the officer to obtain from curves supplied by the builders, the metacentric height at the particular displacement, and thus from further curves the height of the centre of gravity above the keel may be obtained. Any further stowing is thus controllable, and by a simple moment calculation the initial stability may be simply determined. The much more fundamental problem of adequate initial stability for various classes of vessels is one in which the co-operation of captain and the builder is especially desirable. If the captain definitely logs his stability experience, the builder can thus obtain vital design information. The author discusses existing practice in the provision of initial stability and gives diagrams showing the diminution of average initial metacentric height with increasing displacement and decreasing ratio of structural height to draught. Various other technical aspects of stability are discussed, such as the effect of waves in deep water, and also in shoaling water as effecting the rolling of ships.—*Dr. E. Foerster, Werft, Reederei, Hafen*, November 7, 1922, p. 685 ; 7 pp. ; 7 ff.

Hull Scantlings.

This article is a reprint of the paper recently given by the author, Prof. Mengoli, at the annual meeting of the members of the Collegio degli Ingegneri Navali e Meccanici, Genoa, Italy. The diversity of the degree of longitudinal numeral is first commented upon. It is shown that Bureau Veristas require a number of the third degree, Lloyd's one of the second degree [*i.e.*, L(B + D)] and British Corporation one of the first degree. The subject is then treated more technically, expressions being deduced for the longitudinal bending moment coming upon a ship among waves, in terms of the principal dimensions of the ship. Next the considerations governing the choice of permissible stress are discussed. The relation between draught and depth as required by the classification societies is considered, and this completes the external part of the problem. The subsequent portion is first devoted to the calculation of the section moduli of box-shaped single- and double-bottom vessels of varying beam depth ratio and amount of deck opening. Very complete tables are given, giving for these various classes of vessels, coefficients from which the section modulus can be quickly determined. These section moduli are calculated in terms of the mean thickness of the hull, and thus once a given thickness has been decided upon, the thickness can then be very simply determined. This is shown to vary as the square of the length, but when the resulting curve is replaced by a straight line the resulting formula gives results about 10 per cent. less than the similar expression published by the 1915 Freeboard Commission. The article forms an interesting contribution to the subject of ship scantling determination.—*Professor E. Mengoli, La Marina Italiana*, November, 1922, 6 pp. ; 3 ff.

The Frictional Resistance of Ships.

In this article, the conclusion of the series referred to in last month's "Foreign Notes," the author completes the mathematics of his suggested method of separating the wavemaking and frictional resistances of a ship model. The method is illustrated by

an example from McEntee's work on the frictional resistance of planks of different surface nature. The method shows that the simpler method of keeping the speed exponent constant and modifying the intensity coefficient is the best for practical purposes. The article concludes with a reference to some earlier work of Dr. Gebers, in which the latter points out that the form and frictional resistances of ships are not, as usually supposed, independent, but exercise an influence on each other. At the same time, the author points out that Dr. Gebers in the same work (see "Johow-Foerster Hilfsbuch für den Schiffbau, 1920," p. 315) states that the Froude method is the only valid and reliable method available, and as this embraces the segregation of form and frictional resistance, the author considers that Dr. Gebers' statements are in this connection inconsistent. The author finally suggests that the validity of his method can be definitely established by experiment upon a model with three different natures of wetted surface.—*W. Den Boer, Scheepsbouw en Scheepvaart*, November, 1922, p. 193; 2 pp.

Model Experiments on Simplified Merchant Ship Forms.

Simplification of ship form is usually looked upon as a war-time measure and without any purpose or justification in normal times. In Germany, where the high relative costs of construction make every economy considerable, the author is of the opinion that the straight-sided ship is still a possibility. A normal ship of 6,000 tons, for which complete model experiment data existed, was used as a type ship, and eleven different simplified forms were tried against it. Generally these forms were distinctly inferior to the normal, although in the best model a saving of 15 per cent. was actually effected in the power. In this model the shape of after sections was 40 deg. and of the forward sections 6 deg. Complete body sections and model experiment information is given for all the models tried. The models were also tried with propellers attached, and in this case the differences previously existing between the various models are considerably minimised. The best simplified model is still slightly superior, but experimental errors invalidate the absolute value of the comparison. The length of the models were approximately 12 feet, and thus unsteady results were to be expected at the low speeds experimented upon. In the subsequent issue the author deals with the possibility of twin-screw simplified form ships. The normal vessel had a displacement of 17,610 tons, and three simplified forms were tried, naked and with propellers attached. In every case, however, the normal ship was superior. From the results of the research the author concludes that simplified single-screw forms are justifiable departures from existing practice, due to their lower constructional costs and possibly lower running costs. As to their possible ugliness the author very aptly quotes the utilitarian æsthetic principle, "Schön is das, was praktisch ist."—*Dr. G. Zeyss, Werft Reederei Hafen*, October 7, 22, 1922, p. 611, 649; 20 pp.; 26 ff.

Model Experiment Tank Methods.

The purpose of model experiments is to obtain data from which, by the application of the principles of similarity and by faithful duplication of the full-size ship conditions, the powering of the ship may be reliably estimated. Everything depends upon how faithfully the duplication of conditions has been sought after. Many differences of procedure exist in different tanks which, although apparently insignificant, are sufficient to produce appreciable and disconcerting errors in the estimation of S.H.P. of the vessel. One principal difference is the method of obtaining the point of self-propulsion in a "joint" experiment. Usually this is considered to be where the thrust of the propeller is equal to the actual resistance of the model. This, however, is not a faithful duplication of the full-size ship conditions, for it is well known that the frictional resistance of the model is relatively too great. Thus it is essential that the thrust of the propeller be relieved by an amount which represents the difference between the model frictional resistance and that of the ship reduced. This reduction of thrust is accomplished by actually towing the otherwise self-propelled model by an amount equal to the frictional correction. Obviously, the correction will differ with the size of vessel that the same model has to represent. The correction can be very simply expressed in terms of the scale ratio and the calculated actual frictional resistance of the model. Dr. Kempf, the author, then shows the application of the method to the case of a river tug-boat and practically complete accord between the model predictions and actual results obtained on trial was attained. The subsequent portion of the article describes an interesting and useful diagram for tugs, upon which a considerable amount of information is placed. On a base of revolutions the value of tow-rope pull divided by the I.H.P. is plotted over a range of speeds. The power and pull are also separately plotted on the revolution base over the same range of speeds. The quay trial data comes in very useful in giving a limiting value for zero translational speed to the quantities power and pull at each revolution. In the case of tugs, the mooring trial provides a very valuable confirmation of the model experiment research.—*Dr. G. Kempf, Werft Reederei Hafen*, October 7, 3 pp.; 3 ff.

Precautionary Measures on Board Oil Tankers.

This article forms a most comprehensive treatment of the precautions to be observed in the carriage of all classes of oil cargo. In the first chapter the most important properties, such as density, flash point, &c., of the usual classes of oil are discussed. Explosive mixtures are also treated very fully. Next, ten typical types of explosion are given, each supplemented by data of actual explosions which have been reported upon. The elimination of explosive mixtures by means of a gas-ejector system is next treated at considerable length. The general regulations to be observed when loading or discharging and repairing tankers, especially with regard to the use of naked lights, are next detailed. The loading and discharging of oil is separately considered under loading, &c., from shore tanks, from barges and from other tankers, in dock and at sea. For the repairing of tankers the processes of tank cleaning and gas elimination are next considered. In the next portion of the article the precautions to be observed on ordinary vessels burning oil as fuel are dealt with, and in the final chapter precautions of a general nature and interest are considered. Electric sparks caused by short circuits, fusing and breaking of lamps, together with the usual and most efficient means of combatting any outbreak of fire as a result of them, are treated very fully. The article is remarkably complete, and is worthy of the attention of all interested in the transport of oil.—*M. Denier, Bulletin Technique du B.V.*, October, 1922, p. 225; 13 pp.; 2 ff.

ENGAGEMENTS FOR DECEMBER.

Manchester Association of Engineers.—Meeting in Memorial Hall, Albert Square, on Friday, December 8, at 7 p.m. "Boiler Plant Efficiency," by W. M. Selvey, Wh.Sc., M.I.E.E.

Institution of Engineers and Shipbuilders in Scotland.—Meeting in Rankine Hall, 39, Elmbank Crescent, Glasgow, on Tuesday, December 19, at 7.30 p.m. Papers and discussion.

Belfast Association of Engineers.—Meeting in Municipal College of Technology, on Thursday, December 14, at 7.30 p.m. "Marine Steam Turbines and Gearing," by Andrew Hutton, Wh.Ex.

Liverpool Engineering Society.—Meeting at the Royal Institution, Colquitt Street, on Wednesday, December 13, at 8 p.m. "Water and Water Power," by D. Halton Thomson, M.A.(Cantab.).

Junior Institution of Engineers.—Meeting at 39, Victoria Street, Westminster, S.W., on Friday, December 8, at 7.30 p.m. "The Michell Thrust Bearing," with slides and exhibits, by John Ward, B.Sc. Tuesday, December 12, meeting at the Royal United Service Institution, Whitehall, S.W., at 7.30 p.m., "The Utility of Theory to the Practical Man," by Capt. H. Riall Sankey, C.B., C.B.E., R.E. (ret.).

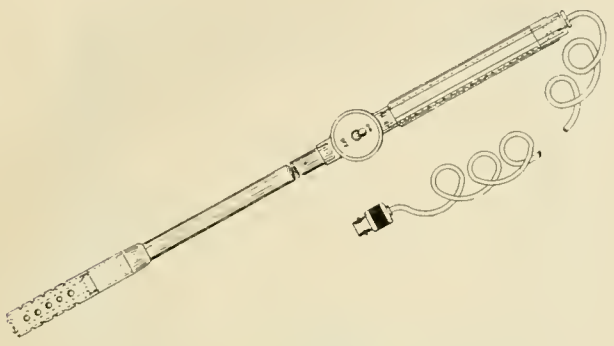
Institute of Marine Engineers.—Meeting at the Institute, the Minories, Tower Hill, London, E., on Tuesday, December 5, at 6.30 p.m. "Marine Diesel Engines," by A. J. Brown. Tuesday, December 12, "Manufacture of Solid-Drawn Steel Tubes," with lantern views, by Engr.-Capt. J. A. Richards, C.B.E., R.N. Tuesday, December 19, Film illustrating Industrial Works: Messrs. Hadfields. Ladies invited.

North-East Coast Institution of Engineers and Shipbuilders.—Meetings in Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne, on Friday, December 8, at 7.30 p.m. "Note on the Presentation of Model Experiment Data," by E. V. Telfer, M.Sc. Friday, December 15, "Wireless Broadcasting and its Possibilities," by A. P. M. Fleming.

Institution of Mechanical Engineers.—*North-Western Branch.* Meeting in Memorial Hall, Albert Square, Manchester, on Thursday, December 7, at 7 p.m. Thomas Hawksley lecture "Some Recent Researches on Lubrication," by Dr. T. E. Stanton, C.B.E., F.R.S. (Member of Council).—*Yorkshire Branch.* Meeting in Philosophical Hall, Park Row, Leeds, on Friday, December 8, at 7.30 p.m. Thomas Hawksley lecture (as above).—*Midland Branch.* Meeting in Birmingham University, Edmund Street, on Wednesday, December 13, at 7.30 p.m. Thomas Hawksley lecture.

LIGHTING OIL FUEL BURNERS ELECTRICALLY.

One of the difficulties met with in the operation of oil-fired boilers on board ship is the starting up of the oil-fuel burners. The usual method adopted consists in burning some waste soaked in fuel oil underneath the burner until the temperature has risen sufficiently high to ignite the oil when it is pumped through the burner. Sometimes the oily waste gives place to some form of flame torch which has first of all to be set burning before being applied to the burners. Both of these methods suffer from the grave disadvantage that they involve the use of a naked flame in the stokehold. This is obviously accompanied by certain grave risks in view of the fact that the atmosphere in the stokehold may be laden with the highly inflammable vapours which are often given off by fuel oil, and further, there is always the possibility of oil accumulating in containers and savealls, or being spilled on the stokehold flat, and if this should accidentally come in contact with a naked flame the danger of fire is very great.



The White Electric Igniter.

With a view to minimising the danger of fire in the boiler room, many attempts have been made to produce a device for igniting oil-fuel burners which shall supersede the use of the naked flame, and one of the simplest and best of these which has so far been brought to our notice is the White Electric Igniter which has just been put upon the market by the White Patent Oil Burning Company Limited, of Newcastle-upon-Tyne. This igniter has been produced by the inventor of the well-known White patent oil-burning system as the result of repeated experiments, and it is claimed that it yields a practical and efficient method for igniting the oil as it issues from the oil-fuel burners. As will be seen from the drawing reproduced herewith, the igniter consists of a handle carrying an ordinary tumbler switch, while at the other end is a heater element which becomes red hot when current is passed through it. The White electric igniter is adapted for use with the ordinary electric light circuit on shipboard, and is made for voltages of 100 to 120, which renders it suitable for use on the majority of lighting circuits found on board ship, and it is provided with a flexible cab-tyre cable carrying a plug as shown, or an adaptor so that it can be connected up to any lamp holder or to a plug connection, according to what is available. In order to ignite the burner, the heater element of the igniter is inserted in the sight-hole in the furnace door and the current switched on. The element quickly becomes red hot and, on opening the valve on the burner, the spray of oil is immediately ignited. It is stated that only a few seconds are required to bring the element to a red heat.

The igniter is of handy size, measuring only 3 ft. 3 in. in length overall, and it is supplied with two clips for attaching to any convenient point in the boiler room.

RECENT PATENTS RELATING TO MARINE ENGINEERING.

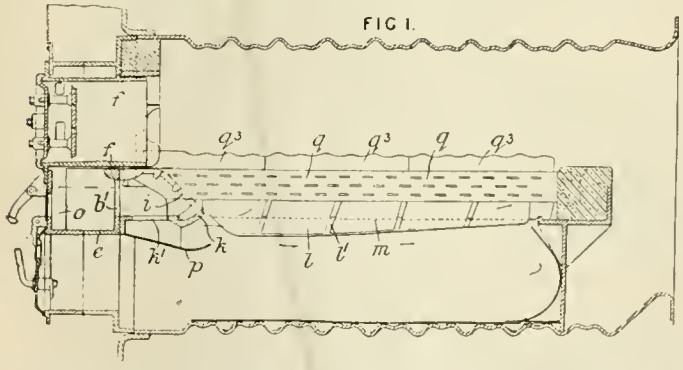
Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 185,784. Furnaces.

Reid, J., 4, *Lloyds Avenue, London. April* 12, 1921, *No.* 10704. [*Class* 51 (i).]

In steam boilers provided with internal furnace flues, air is supplied to the fuel on the grate, which is arranged below the level

FIG 1.



of the firing-opening, through slotted bars q arranged at the sides of the grate and serving to protect the flue and through the spaces

FIG.2.

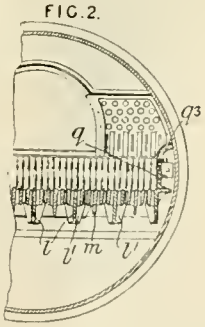
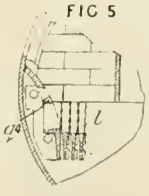


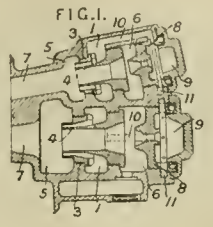
FIG 5



between inclined bars i arranged at the front of the grate bars l. Air passes from the hollow forced-draught front to the space between the firing-opening f and partition wall e and is directed by a partition o through ports b^1 into the space beneath the bars i. Part of such air passes to the chambers formed between the bars q and the furnace flue and closed at the top by bars q^3 while the remainder passes between the bars i and through openings k^1 in the bearer k whence it is directed by a plate p into passages formed between the fire-bars l. Ribs l^1 serve to direct the air upwardly to the fuel on the bars l between which are arranged shallow bars m. Fig. 5 shows a modified form of bar q^4 arranged at the sides of the grate to form chambers communicating directly with the ash-pit. Air may also enter the side-chambers directly from the hollow front. Specifications 182,498 and 183,508 are referred to.

No. 186,320. Ejectors.

Soc. dite Freins Jourdain-Monneret, 30, *Rue Claude Decaen, Paris. August* 26, 1922, *No.* 23214. *Convention date, September* 19, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 71.]



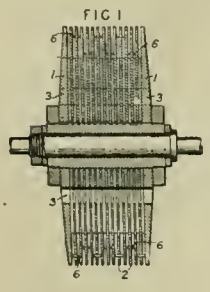
In brake ejectors in which convergent-divergent cones are arranged in series for multiple-stage working, steam injected through a rear divergent steam-nozzle 8 operates on the air in an induced-fluid chamber 6, connected to the train-pipe, and then, while mixed with the air from this chamber, is acted on, at the forward end of a nozzle 4, by a fresh supply of steam issuing, by an annular nozzle 3, from the main steam-supply chamber 1, which also supplies a rear steam chamber 9, feeding the nozzle 8, by means of grooves 10, 11. A chamber 5 is provided between the nozzle 4 and the discharge pipe 7. Straight or slightly helicoidal grooves may be provided on the interior of the cone 3 so as to direct the jets and avoid the formation of eddies.

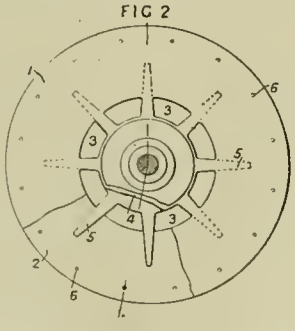
The flow of steam between chambers 1 and 9 may be regulated by a device inserted in the conduit 10.

No. 186,082. Turbines.

Tesla, N., 8, *West Fortieth Street, New York, U.S.A. March* 24, 1921, *No.* 9097. [*Class* 110 (iii).]

Operated by fluid friction.—In a turbine of the type described in Specification 24001/10, the rotor is made up of a number of parallel

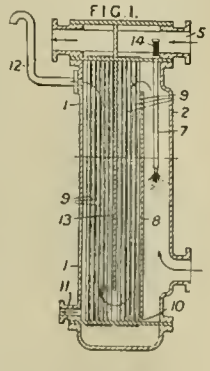




discs 2 perforated at 3 to provide exhaust passages, spaced apart by star-shaped plates 4 or circular washers not extending beyond the perforations 3, and clamped between stout end discs 1. The discs 2 are held separate at their outer portions by spacing pins 6 or by projections pressed out on one side of each plate.

No. 186,122. Condensers ; water-heaters.

Higgins, C. F., 3, *Central Buildings, Westminster. June* 15, 1921, *No.* 16534. [*Classes* 32 *and* 64 (i).]

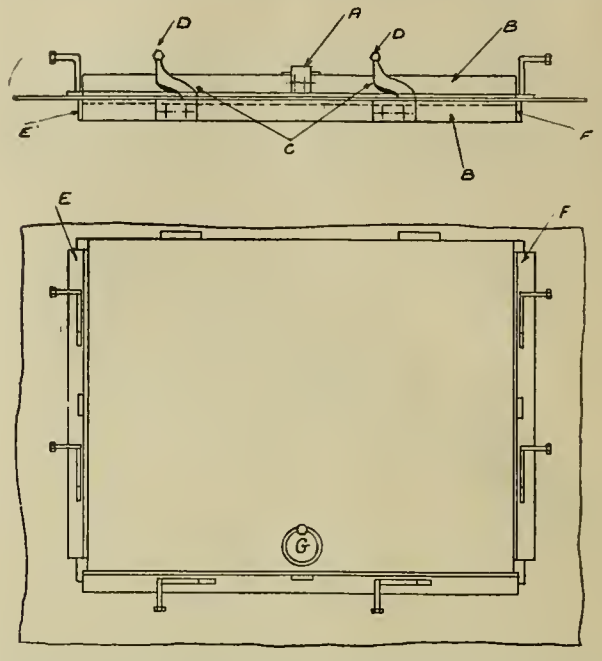


In apparatus for condensing superheated steam, or for heating water by means thereof, in which the steam is first deprived of its superheat by bringing it into contact with a jet of water and is then further condensed in a surface-apparatus, the jet and the surface-apparatus are contained in a single casing. In the form shown the steam is guided by baffles 8, 13 in the casing 1, first through a chamber 2, where it meets a jet 7 of water, and then over pipes 9 through which water is passed. The water for the jet 7 may be taken from the inlet 5 to the pipes 9, passing on its way through a strainer 14. Water deposited in the chamber 2 escapes through an opening 10 in the baffle 8, and is discharged along with the condensate through an outlet 11. An air outlet 12 is also provided. A modification is provided with two jets.

No. 166,371. Improvements in Smoke-Box Doors for the Furnaces of Boilers and the like.

Henry John Herbert Hollanders, 24, *Macaulay Road, East Ham, London, E.* 6, *and John Peter Hollanders*, 48, *Compton Avenue, East Ham, London, E.* 6. *May*, 6, 1920.

The nature of this invention is as follows :— An easy method of fastening a smoke-box door, also preventing same from buckling, making it possible for the door to be opened and closed by one man, the fittings being on the smoke-box instead of on the door, making same much lighter, and much time would also be saved in the operation.



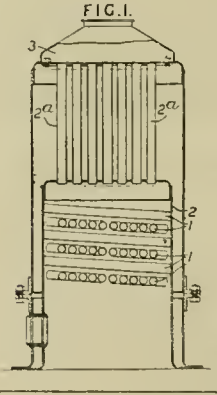
Should this invention be adopted, the original door could be used and the fittings attached in a very short time and without great expense and little material ; it would also add to the strength of the door.

Lugs are bolted on to the angle-bars inside the smoke-box and are fitted through a slot in front of the smoke-box, causing the jaws in the lugs to project alongside of the door.

An angle-bar, with a slot cut in the flange, drops into the jaws of the lugs and a few blows with a hand hammer causes the door to be clamped between the angle-bars outside and inside the smoke-box.

No. 186,269. Steam-generators.

Hazell, R. L. K., 23, *Lexden Street, Lexden, Essex, and Davey, Paxman & Co. Limited, Standard Iron Works, Colchester. November* 11, 1921, *No.* 30137. [*Class* 123 (ii).]



Vertical boilers.—A steam-generator comprises in combination a plurality of approximately horizontal rows of water-tubes 1, of segmental shape of varying ares arranged in the fire-box 2 in two or more groups and a plurality of vertical or approximately vertical smoke tubes 2a passing through the water and steam space leading from the fire-box to a common smoke-box 3 forming the top of the generator.

OFFICIAL NOTICES.

THE owner of Patent No. 25212 of 1912, for Improvements in or relating to the Rolling of Metal Bars and the like, desires to license or sell the patent rights in Great Britain. Address: E. P. Alexander & Son, Chartered Patent Agents, 306, High Holborn, London, W.C.1.

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PATENTS AND DESIGNS ACTS, 1907 AND 1919.

MARINE TORCHES.

THE Proprietor of British Lettera Patent No. 135,712 is prepared to sell the Patent or to license British manufacturers to work under it. It relates to torches in which illuminating gas is automatically generated and ignited when the torch is thrown into the water.

Address: B. W. & T.,
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vol.45. 1922.

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